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JOSEPH A. CUSHMAN, Editor

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JOURNAL OF PALEONTOLOGY

MARCH 1929

A BRYOZOAN FAUNULE FROM THE UPPER GRAHAM FORMATION, PENNSYLVANIAN, OF NORTH CENTRAL TEXAS

RAYMOND C. MOORE

ABSTRACT

A prolific, well preserved bryozoan faunule from the Wayland shale, topmost member of the Graham formation of the Cisco group, in north central Texas, is described. The material comes from a locality about five miles east of Cisco, in Eastland County. A large number of new species and varieties is recognized and one new genus is proposed.

INTRODUCTION

In abundance, variety, and excellent preservation, the invertebrate fossils of certain parts of the Pennsylvanian strata of the Mid-Continent region are surpassed by few fossiliferous deposits in the world. Despite these facts the difficulties in utilizing the paleontologic testimony for detailed regional correlations have apparently distinguished the Pennsylvanian strata from other geologic divisions in which faunal zones are clearly marked and readily identified. A majority of the species seem to be long ranging. Not only do certain shells, as commonly identified, occur at intervals from the bottom to the top of the Pennsylvanian column, but the composition of two faunas stratigraphically separated by hundreds of feet may appear almost identical. Thus it is not surprising that the main basis of classification of the Pennsylvanian in this region has been lithologic and physiographic rather than paleontologic, and that in places,

as in parts of southern Oklahoma where it is not possible to trace the beds of one area into those of another, there is much difficulty in precise determination of stratigraphic equivalents. The correlation of the divisions of the north Texas section with those of the Ardmore basin, and these in turn with the deposits north of the Arbuckle Mountains furnishes a problem, the solution of which is of utmost importance to the correct understanding of the historical geology of this portion of the continent. It is undoubtedly possible to solve these problems definitely. Studies of lithologic and diastrophic evidences will aid greatly, but the most important criteria will be paleontologic.

The present paper is one of a series in which the attempt will be made carefully to scrutinize various elements in our Pennsylvanian faunas. It is hoped that by greater precision in recognition of species more definite paleontologic comparisons will be made possible.

A group of bryozoans from the Wayland shale, uppermost member of the Graham formation of the Cisco group in north central Texas, has been selected as the subject of the present study because of the large quantity of beautifully preserved material at hand and because we believe that this group of invertebrates, demonstrated as one of the most valuable aids to the worker in stratigraphic paleontology will be most useful for purposes of regional correlation. Bryozoans are very numerous in certain Pennsylvanian and Permian formations of the Mid-Continent. Another reason for taking up the investigation of the Graham bryozoan faunule is the fact that most of the paleontologists who are actively at work on Pennsylvanian fossils are devoting their attention to other invertebrate groups, mainly the foraminifers and ostracodes.

All the material described in this paper was obtained at locality 89.1 of Plummer and Moore (Stratigraphy of the Pennsylvanian formations of north central Texas, Univ. of Texas Bulletin 2132, page 226, 1921) which is five miles east of Cisco and about the same distance west of Eastland on the Cisco-Eastland road, about 2,000 feet north of the paved highway where the old highway turns due north from the pavement and in about a quarter of a mile turns due east. The locality is about 1,000 feet north of this eastward turn in the old road. The shale here is extremely fossiliferous, the larger fossils corresponding exactly in character and mode of weathering to those obtained in other places from the Wayland shale. One thin limy shale zone contains larger numbers of crinoid stems and bryozoans and is the source of most of the bryozoan material gathered here.

We wish especially to acknowledge the assistance of our colleague, Mr. F. B. Plummer, who assisted in making original collections at this locality a number of years ago and who joined in revisiting the locality in the summer of 1927 and in the early spring of 1928. Thanks are also due Dr. R. S. Bassler and Dr. G. Dallas Hanna for helpful suggestions in preparing illustrations, and Harold Hawkins, our photographic assistant.

In this paper a description of the species recognized will be offered and a consideration of regional correlation will be reserved until a later time. The types, retained for the present in our collection at Lawrence, Kansas will later be deposited in the National Museum at Washington.

DESCRIPTION OF SPECIES

Class BRYOZOA Ehrenberg

Order GYMNOLAEMATA Allman

Suborder CYCLOSTOMATA Busk

Family FISTULIPORIDAE Ulrich

Genus FISTULIPORA McCoy

FISTULIPORA INCRUSTANS Moore, n. sp.

Plate 1, figs. 1, 2, 6, 8; figs. 1 *a*, *b*

Zoarium a thin incrusting expansion on crinoid stems, *Polypora*, shell fragments, and other foreign substances. One of the cotypes is a flat bifoliate expansion about 15 mm. in diameter, growing on both sides of a thin limy lamella. The surface is very nearly even; in places there are almost imperceptible swellings and there are very slightly depressed maculae rather regularly distributed over the zoarium and about 6 mm. apart. The zooecia are short, tubular, without diaphragms and are normal or slightly inclined to the surface. Those adjacent to the maculae are noticeably larger than the remainder. The average length of the tube, which represents the thickness of the zoarium, is about .5 mm. and the maximum is only slightly more than 1 mm. Apertures subcircular to elliptical, .36 to .55 mm. in diameter, surrounded by a distinct, moderately elevated, thin peristome which shows in many cases a rather prominently elevated lip and distinct lunarium. In most of the zoarium a single row

of angular thin-walled mesopores occurs between the zooecia, but locally there are two to four rows between the zooecia and the maculae contain large numbers of them. Longitudinal sections show moderately even-spaced diaphragms in the mesopores, the spacing in general being distinctly less than the diameter of the pores; about ten occur in 1 mm. In some of the specimens and parts of specimens there is no regular arrangement of the apertures, but in others they are evenly arranged in intersecting rows, ten apertures occupying the space of 5 to 6 mm. The average interval between the zoœcia is .12 mm.

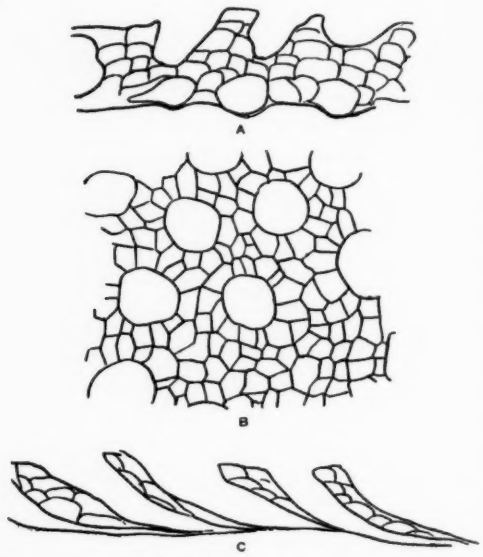

FIG. 1 *a, b.—Fistulipora incrustans* Moore, n. sp. *a*, longitudinal section, ×20; *b*, tangential section, ×20. *c*, *Fistulipora incrustans* var. *regularis* Moore, n. var , longitudinal section, ×20.

Incrusting forms of *Fistulipora* in the Pennsylvanian of this country have been referred rather uniformly to Meek's species *F. nodulifera.* However, that species has smaller zoœcia, measuring .2 to .27 mm. in diameter, wider interspaces averaging .23 mm., commonly developed irregular elevations or nodules on the surface, lacks maculae, internally the diaphragms of the mesopores or the vesicles measure about ten in .6 to .68 mm., and there are rather regularly two or more rows of mesopores between the zoœcia instead of only one as in most cases in the Texas forms here described. In one specimen from the Wayland shale the vesicles correspond in size to those of *F. nodulifera* but all other measurements and characters of the zoarium correspond to *F. incrustans. F. nodulifera* has ten apertures in about 3.7 to 4.2 mm.

FISTULIPORA INCRUSTANS var. REGULARIS Moore, n. var.
Plate 1, figs. 3-4; fig. 1 *c*

A form represented in our collection by several beautifully preserved specimens is rather easily distinguishable from typical *F. incrustans* but apparently should be regarded as a variety of that

species. The zoarium is a very thin incrusting growth, generally found on crinoid stems; it reaches an observed width of about 40 mm. and a maximum observed thickness of .45 mm. A specimen growing on *Fistulipora vaccula* Moore, n. sp., is shown in Pl. 1, fig. 11. The zooecial tubes are notably recumbent, rostrate and subtrigonal in cross section in the immature region, rounded and meeting the surface at an angle in the apertural region. The tubes are about 1.5 mm. in length and the directions of growth are clearly evidenced both from the backward slope of the anterior wall seen at the aperture and by the position of the rather strongly developed lunarium located on the dorsal posterior side. The lunarium is not extended as a hood. Apertures rather evenly about .4 mm. in diameter arranged in distinct intersecting slightly curved rows, more or less quincunxial. Ten apertures occur in 5 mm., the interspaces measuring about .15 mm. Mesopores rarely form more than a single row between zooecia. The surface of the zoarium is further distinguished by the regular distribution of small maculae about 1.5 mm. in diameter and about 4 mm. apart. The zooecia around the maculae are only slightly larger than the average.

This variety is distinguished from *F. incrustans* by the regularly disposed small maculae and the very regular arrangement of the zooecia as well as by its much thinner incrusting form.

FISTULIPORA NODULIFERA var. MACULOSA Moore, n. sp.
Plate 1, figs. 9, 12

In mode of growth, the presence of small nodes spread over the surface, measurements of zooecia and their spacing, and the arrangement of mesopores this form from the Wayland shale appears to correspond almost exactly to *F. nodulifera* Meek. The apertures measure .24 to .29 mm. in diameter and the average interzooecial space is slightly less than the apertural diameter; ten apertures occur in 3.8 to 4.1 mm. There are approximately as many cases where two to four rows of mesopores occur between the apertures as where one row occurs. The chief distinguishing feature is the presence of distinct maculae which occur at somewhat evenly spaced intervals of about 5 mm. In some cases the maculae form flattened or slightly depressed non-poriferous areas on the flanks of the monticules but in others there is no monticule adjacent. Longitudinal sections show the mesopore vesicles slightly more crowded than in figured specimens of *F. nodulifera;* ten vesicles occur in about .4 to .45 mm.

F. nodulifera maculosa is readily distinguished from associated

incrusting species of this genus in the Wayland shale by its smaller and more closely spaced apertures, and by the presence of small monticules.

FISTULIPORA VACCULA Moore, n. sp.
Plate 1, figs. 5, 7, 10, 11

Zoarium massive, compressed ellipsoidal or irregular, commonly 10 to 15 centimeters across by 4 to 8 centimeters thick; occasional specimens up to nearly a foot across have been seen. Surface gently uneven bearing low rounded monticules about 8 or 9 mm. apart, and smooth, flat or slightly depressed maculae about 2 mm. in diameter generally about 10 mm. apart. The zooecia are long, tubular, with comparatively straight thin walls and, as seen in longitudinal sec-

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EXPLANATION OF PLATES

PLATE 1

FIGS. 1, 2, 6, 8.—*Fistulipora incrustans* Moore, n. sp. 1, portion of the surface, ×10; 2, surface of a cotype showing maculae, ×2.5; 6, tangential setion, ×10; 8, longitudinal section, ×10.

3, 4.—*Fistulipora incrustans* var. *regularis* Moore, n. var. 3, portion of the surface of a cotype, showing maculae, ×2.5; 4, a portion of this specimen, ×10.

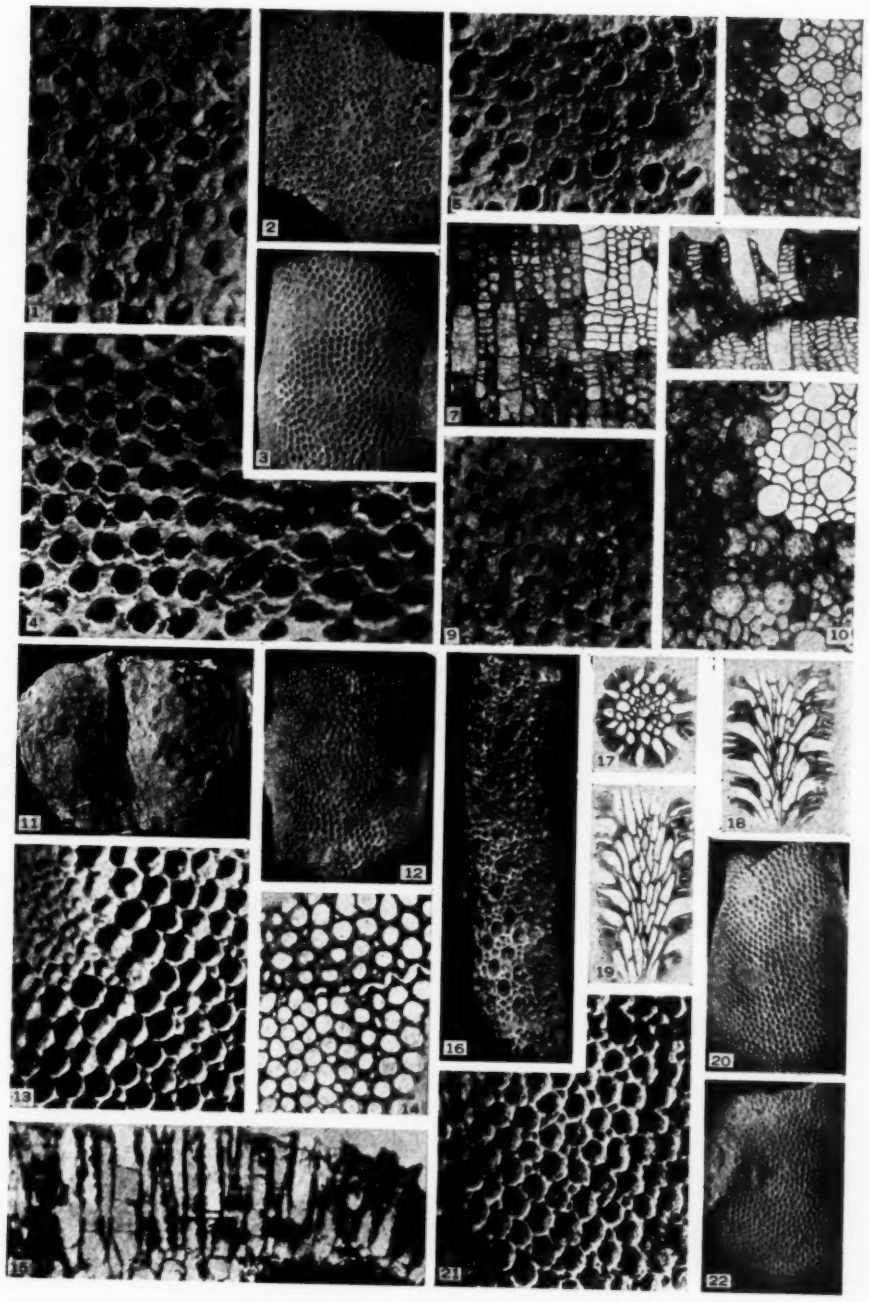
5, 7, 10, 11.—*Fistulipora vaccula* Moore, n. sp. 5, portion of the surface, showing a macula at right, ×10; 7, part of a longitudinal section, ×10; 10, tangential section, ×10; 11, surface of a cotype, ×¼; a small incrusting colony of *F. incrustans* Moore, n. sp., may be seen on the upper left hand part of the specimen.

9, 12.—*Fistulipora nodulifera* var. *maculosa* Moore, n. var. 9, portion of the surface, ×10; 12, view of a portion of the type, ×2.5.

13–15, 20.—*Tabulipora cava* Moore, n. sp. 13, portion of the surface of a cotype showing a macula, ×10; 14, tangential section, ×10; 15, longitudinal section, ×10; 20, view of a portion of a zoarium showing distinct maculae, one of the cotypes, ×2.5.

16–19.—*Leioclema hirsutum* Moore, n. sp. 16, surface view of a cotype, ×10; 17, transverse section of another specimen, ×10; 19, longitudinal section of same, ×10; 18, longitudinal section of another specimen, ×10.

21, 22.—*Tabulipora plummeri* Moore, n. sp. 21, portion of the surface of the type, ×10; 22, a portion of the surface of the type, ×2.5.



UNIV OF MICH.

tions, bearing diaphragms normal or inclined to the cell walls, in places more than 1 mm. apart, elsewhere about .2 mm. apart. Apertures subcircular, surrounded by a thin peristome, in parts of the zoarium separated by less than one-fourth their diameter but elsewhere by more than twice the diameter which measures .35 to .5 mm. On the average about 6 apertures occur in 4 sq. mm. As seen in tangential sections some of the apertures bear an indistinct lunarium. Mesopores angular, thin-walled, comparatively large and forming one to four rows between zooecia.

F. vaccula is chiefly distinguished by the robust size and the form of the zoarium. Stained brown by iron oxide, the appearance of many of the specimens that have weathered from the shale, rather strikingly resembles the dung of a cow. Among Pennsylvanian Fistuliporas this species most closely resembles *F. carbonaria* Ulrich and *F. zonata* Girty. It differs from *F. carbonaria* in the general shape of the zoarium, in the presence between many of the zooecia of the two to four rows of cysts and in a number of other characters. *F. zonata* has two or more rows of mesopores between some of the zooecia, but lacks maculae, has relatively smaller zooecia and mesopores, a rather striking zonate arrangement of cysts and diaphragms, and is apparently altogether a less robust species.

Suborder TREPOSTOMATA Ulrich

Family BATOSTOMELLIDAE Ulrich

Genus TABULIPORA Young

TABULIPORA CAVA Moore, n. sp.

Plate 1, figs. 13-15, 20

Zoarium subcylindrical and hollow, irregularly ramose with bulbous swellings; diameter of branch 6 to 15 mm., thickness of zooecial layer 1.5 to 3.5 mm. Surface smooth except for minute projections of acanthopores. Small undepressed maculae composed of crowded polygonal mesopores and bordered by zooecial apertures slightly larger than ordinary occur at somewhat regular intervals of 3 to 4 mm. Apertures rounded to subpolygonal, ranging in diameter from .27 to .37 mm.; in the spaces between the maculae rather regularly arranged in intersecting rows, 13 in 5 mm. The interspaces between the apertures range in thickness from .03 to .2 mm., in a

few cases rounded but generally rising to a sharp edged crest which sags between the angles of the cells where the projecting acanthopores occur. Angular to rounded mesopores are very rare in the portion of the zoarium where the zooecial tubes are regularly arranged, but elsewhere they are about as numerous as the zooecia and they are closely crowded in the maculae. Acanthopores large, up to .1 mm. in diameter, located at the cell angles, about 5 to each zooecium. In longitudinal sections they are seen to extend the length of the thick portion of the tube and at a distance below the surface they very strongly indent the tubes. The thickened walls are only slightly moniliform. Perforated diaphragms occur in the zooecial tubes at the distance of about the diameter of the tube apart, 4 to 5 occurring in each zooecium.

We have several very well preserved specimens of *T. cava* entirely free from matrix. The species is distinguished by its mode of growth, the spacing of the zooecia, the large and fairly abundant acanthopores, and the character of the maculae. The hollow ramose form of the zoarium is like that of *T. rudis* (Ulrich) from the Chester with which form our species approximately agrees in zooecial measurements. However in Ulrich's species the zooecia are shorter, more sharply inflected, and the acanthopores are smaller and less numerous. In the diameter, in the spacing of the zooecia and in the appearance of certain tangential sections there is a resemblance to *T. cava* Girty, but that form has solid branches, small and few acanthopores and other distinguishing features.

TABULIPORA PLUMMERI Moore, n. sp.

Plate 1, figs. 21, 22

Zoarium incrusting, thin, maximum observed thickness 1.5 mm., the cotypes incrust crinoid stems about 9 mm. in diameter, in one case extending 30 mm. along the stem. Surface smooth without maculae or monticules. Apertures subcircular to subpolygonal, moderately uniform, diameter about 0.3 mm. Interspaces average 0.13 mm., sloping to a sharp crest. In most of the zoarium the apertures are arranged in somewhat regular intersecting series, 14 occurring in 5 mm. Large acanthopores, slightly projecting at the surface, occur at the cell angles, about five or six to each zooecium. Mesopores few except in parts of the zoarium where one or two to the zooecium occur over a considerable space. Zooecial walls thick and not distinctly moniliform. One to three perforated diaphragms occur in each tube.

This species is distinguished from *T. circina, T. hispida* and *T.*

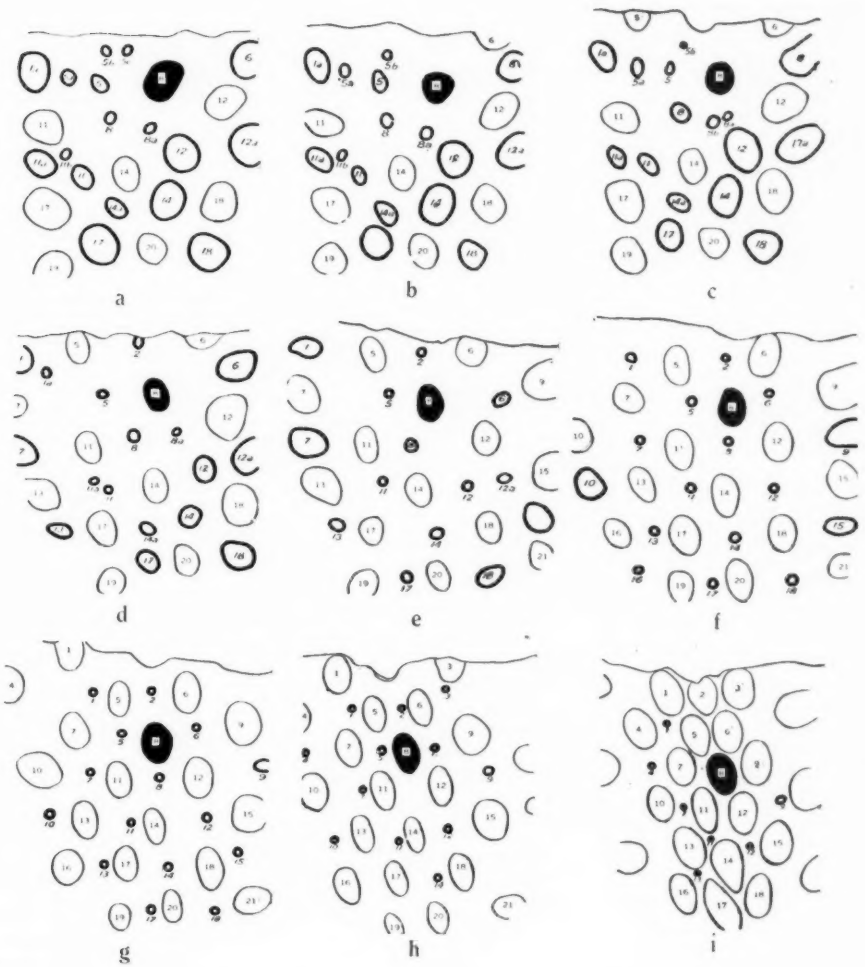


FIG. 1 2.—Tangential section of *Megacanthopora fallacis* at successive depths from the surface (×17.5). The zooecial tubes (except 8, which is colored black for reference) are indicated by light lines, and are numbered serially, beginning in section *i*, near the axial zone where they are readily recognized. The acanthopores are indicated by heavy lines and are numbered in italics to correspond with the zooecium next above. Depths of sections from the surface of the zoarium: *a*, 0.085 mm.; *b*, 0.20 mm.; *c*, 0.34 mm.; *d*, 0.49 mm.; *e*, 0.63 mm.; *f*, 0.77 mm.; *g*, 0.92 mm.; *h*, 1.15 mm.; *i*. 1.30 mm

micropora, described by Coryell and Morgan, by the larger apertures and coarser spacing, absence of prominent beaded thickenings of the walls and other characters. *T. spinulosa* Rogers has monticules and rather abundant small acanthopores, while *T. heteropora* Condra likewise bears monticules and is distinguished by noteworthy unevenness of the apertures, thin walls and other features. Perhaps closest resemblance is found in *T. distans* which has a smooth surface, non-moniliform walls, and approximate agreement in measurements. This species is distinguished by the smaller number of large acanthopores and the presence of numerous small acanthopores. *T. tuberculata* Prout, a Mississippian form with which certain Pennsylvanian forms have been identified by Mather and Condra, has longer and slightly smaller tubes, more numerous diaphragms, and less abundant large acanthopores. *T. plummeri* is named in honor of our valued friend and colleague, Mr. Frederick B. Plummer.

Genus LEIOCLEMA Ulrich

LEIOCLEMA HIRSUTUM Moore, n. sp.
Plate 1, figs. 16-19

Zoarium ramose, solid, or in many cases growing about a *Productus* spine, diameter 1.0 to 1.4 mm. Zooecia subcircular to elliptical, but in many cases the borders are indented by large acanthopores. Mesopores abundant, rounded or subpolygonal in outline, one to three rows between apertures. Acanthopores strongly developed and abundant between zooecia and mesopores, projecting from the surface so as to give the zoarium a distinctly hirsute appearance. Longitudinal and transverse sections show the outer cortical regions to have an average thickness of about .4 to .45 mm. and the axial region a diameter of about .9 mm. In the latter region the zooecia are thin-walled, rounded to polygonal in outline and bear occasional diaphragms. The tubes are at first rather gently inclined to the axis of growth and then bent outward at right angles to the surface. This is the only representative of this genus which has been observed in the Pennsylvanian so far as we are aware and does not closely resemble other described species.

Genus MEGACANTHOPORA Moore, new genus

An interesting group of robust ramose Pennsylvanian bryozoans, study of which has involved various perplexities, is set aside under this name as a new genus. In some specimens or portions of speci-

mens the zooecial apertures are more or less regularly arranged and the zoarium resembles a large *Rhombopora*. In others the apertures are distinctly irregular in arrangement and there may be rounded to subangular openings much smaller than the average intercalated between the normal apertures. The latter may have the appearance of mesopores and have been so interpreted tentatively by Girty[1] in his description of the evidently closely related form which he designates *Batostomella greeniana*. In still other specimens the apertures are rather regularly arranged in vertical and transverse series, but the diagonal ranges are not very evident. In this case the apertures are more or less nearly uniform in size, moderately thin-walled, and the outline tends to be subquadrangular rather than rhomboidal. Occasional irregularities suggesting ill-defined monticules, in some cases composed of cells with distinctly thinner walls than average, are found. Occasionally the space between adjacent apertures is unusually wide and contains thickly crowded micracanthopores.

Transverse sections show that the axial immature area is relatively small, generally constituting one-third or less of the diameter of the stem. The cells here are thin walled, polygonal, have nearly the diameter of the mature tube, and are not very numerous. In the cortical zone the tubes are directed radially in a plane practically normal to the zoarial surface. The walls of the tube are lined with moderately thick, dark, dense tissue, and where the section coincides with the plane of this wall numerous tiny dark round dots appear that presumably represent tubuli penetrating the wall. Both the transverse and longitudinal sections show zooecial tubes that do not appear to extend inward beyond the cortical zone, but such sections are insufficient to show that these are not portions of longer tubes reaching the axial region and that are intersected obliquely.

Tangential sections at shallow depth show more or less thickly crowded zooecia with a bordering thick wall and the intervening interspaces with thickly crowded micracanthopores. Some of the apertures are likely to be distinctly smaller than the average but otherwise not evidently different from the large ones. In the space longitudinally or transversely between adjacent apertures there may be an acanthopore much larger than the normal, but in some cases these are not seen. A tangential section deeper within the zoarium generally shows regularly disposed more or less elongate elliptical apertures in which the intersecting diagonal series are much more prominent than the longitudinal or transverse and at the end of each cell

[1] G. H. Girty in Hines and Greene, Stratigraphy of the Pennsylvanian Series in Missouri, Mo. Bur. Geol. and Mines, 2nd series, vol. 13, page 323.

there is commonly a prominent acanthopore; the remaining portion of the interspaces containing thickly crowded micracanthopores. Such a section is almost identical in appearance with the tangential section of *Rhombopora lepidodendroides*. While the size of the zooecial tubes is not sensibly less than in the shallow tangential section, the interspaces, strange to say, are on the average, distinctly wider and the number of zooecial tubes in a given area is noticeably reduced.

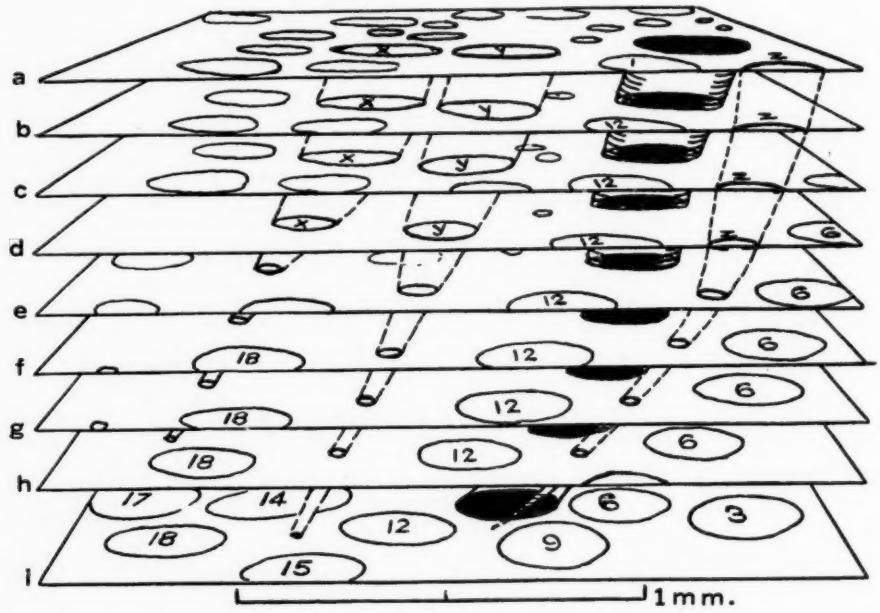


FIG. 3.—Stereographic sketch of the tangential sections of *Megacanthopora fallacis* shown in fig. 2. The enlargement of many of the acanthopores toward the surface is clearly indicated. Acanthopore x=14 of fig. 2; y=12; z=6. Horizontal and vertical scale of the drawing are the same.

By means of successive tangential sections at intervals of about .15 mm. (Figs. 2, 3) the structure of successive depths within the zoarium has been determined and it is found that the seemingly normal large acanthopores of the deeper portion of the zoarium commonly become so enlarged on approaching the surface that in most cases they are indistinguishable from the associated zooecial apertures. The zooecial tubes may occasionally show the presence of a diaphragm, but these have not been observed in the tubes that are

restricted to the cortex. The irregularities in the arrangement and in the size of the apertures at the surface are due to the intercalation of these enlarged acanthopores. Presumably these tubes which do not extend to the axial zone contained zooids of a different nature from that of the normal zooecia. In the inner part of the cortical zone they are indistinguishable from large acanthopores. In studying specimens of the type here described, an oblique tangential section serves very satisfactorily to show the structure at different levels within the stem.

The distinguishing features of *Megacanthopora* are believed to be the expansion of the more or less regularly disposed interzooecial large acanthopore tubes so that at the surface of the zoarium they resemble mesopores or normal zooecia; the thick cortical zone in which the zooecia are lined with a dense tissue perforated apparently by minute tubuli; the presence of occasional diaphragms but absence of hemisepta or a distinct vestibular region. The genotype is *M. fallacis* Moore, n. sp. We believe that the genus should be assigned to the family Batostomellidae.

Students familiar with Pennsylvanian bryozoans will recognize in the foregoing discussion and in the accompanying figures similarities with *Rhombopora crassa* Ulrich aud *Batostomella greeniana* Girty. We have not had opportunity to examine typical examples of these species but they are undoubtedly allied to the Texas forms, and in the case of the latter may prove assignable to *Megacanthopora*. *R. crassa* seemingly lacks megacanthopores and has a moderately regular arrangement of apertures. *R. lepidodendroides* shows the thickened dark lining of the zooecial tubes, megacanthopores and micracanthopores, and appears to lack hemisepta; it is related to our species but is generically extinct. It certainly does not seem proper to refer the species under discussion to different families and suborders.

MEGACANTHOPORA FALLACIS Moore, n. sp.
Plate 2, figs. 1-4; figs. 2, 3

Zoarium ramose, robust, 2. to 3.5 mm in diameter, the average about 2.9 mm., generally straight, branching by bifurcation at irregular intervals, the branches having an angle of about 45 degrees to the main stem. One specimen has a straight portion 25 mm. long, below bifurcating branches 5 to 7 mm. long. We have several straight fragments 15 to 20 mm. long. One specimen, doubtfully referred to this species, gives off a branch laterally. The branches have about the same diameter as the main stem. Zooecial apertures

subcircular, subquadrangular or elongate-ovate, about .26 to .31 mm. in longest diameter. In parts of the specimens the apertures are subequal in size and more or less regularly arranged, longitudinal and transverse series being more prominent than diagonal rows. An average measurement longitudinally shows five apertures and five interspaces in 1.7 to 1.8 mm., and five transversely in 1.6 to 1.8 mm. Elsewhere there are irregularly smaller openings intercalated between the large ones and the distribution may be much less regular. The interspaces are generally rather narrow, rounded and carry one or more rows of granules representing crowded micracanthopores. Where weathered these tend to form small pits. Locally there are acanthopores larger than the average about midway longitudinally or transversely between adjacent zooecial apertures. There appears to be no true vestibular area in the zooecial tubes, the walls sloping very steeply downward. Transverse sections show a prominent division of the stem into cortical and axial zones, the latter occupying about one-third of the diameter of the stem. The measurements of the type are cortex 1.2 mm., axial zone 1.0 mm. The internal char-

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EXPLANATION OF PLATES

PLATE 2

FIGS. 1–4.—*Megacanthopora fallacis* Moore, n. gen. et. n. sp. 1, transverse section of the holotype, ×10; 2, tangential section of the holotype, ×10; 3, a portion of the surface of the holotype, ×10; 4, portion of another specimen, ×5.

5–7.—*Fenestella placida* Moore, n. sp. 5, obverse side of a fragment, ×10; 6, reverse of this specimen, ×10; 7, portion of the obverse side, ×25.

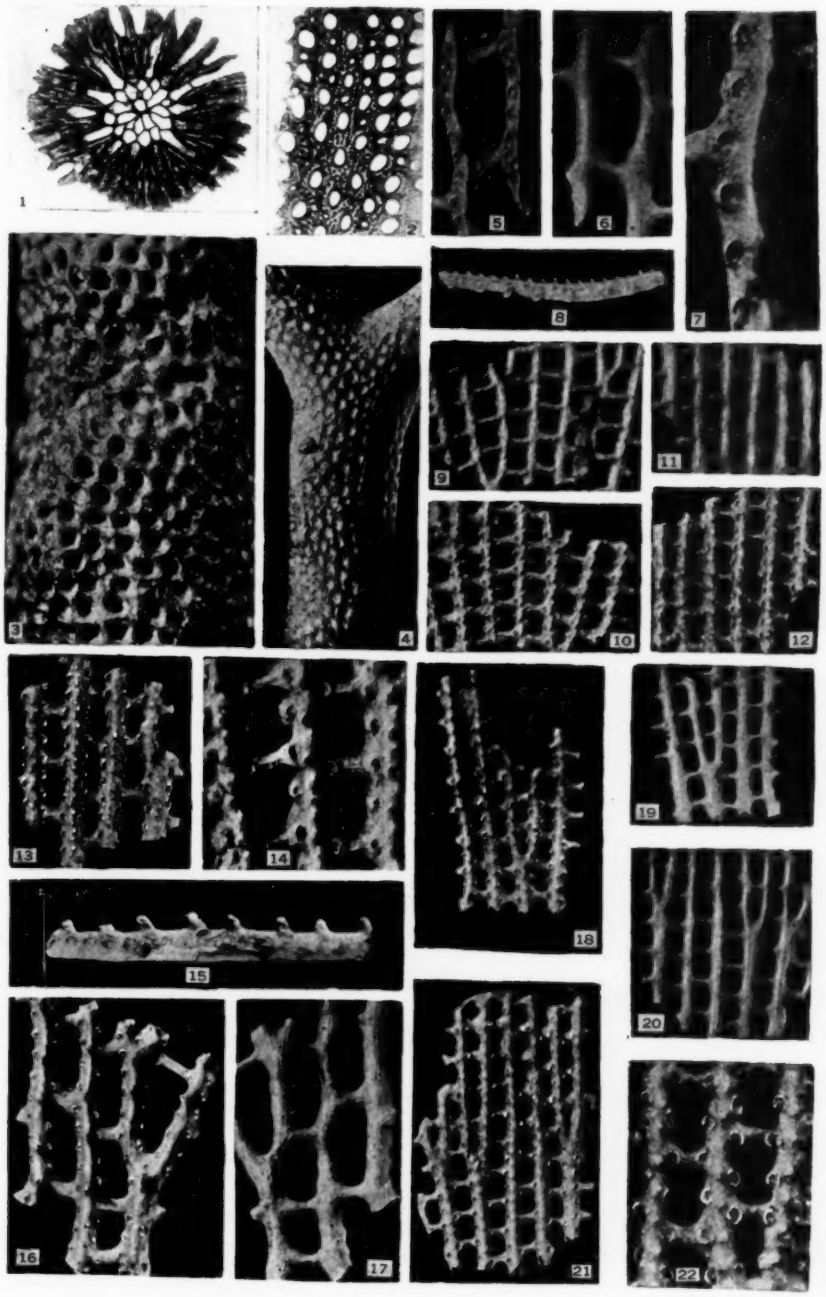
8–10.—*Fenestella pectinis* Moore, n. sp. 8, side view of branch, showing spines, ×10; 9, reverse side of a cotype, ×10; 10, obverse of this specimen, ×10.

11, 12.—*Fenestella plummerae* Moore, n. sp. 11, reverse side of the type, ×10; 12, obverse of this specimen, ×10.

13.—*Fenestella binodata* Condra, obverse, ×10.

14–17.—*Fenestella spinacristata* Moore, n. sp. 14, portion of obverse side, ×25; 15, side view of a branch showing spines, ×10; 16, obverse, ×10; 17, reverse, ×10.

18–22.—*Fenestella mimica* var. *texana* Moore, n. var. 18, obverse view of a cotype, ×10; 19, reverse of the specimen shown in fig. 18, ×10; 20, reverse of another cotype, ×10; 21, obverse of the specimen shown in fig. 20, ×10; 22, portion of the obverse side of the specimen shown in fig. 18, ×25.



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acters have been sufficiently described in discussion of the genus.

Externally *M. fallacis* somewhat resembles *Rhombopora crassa* Ulrich, and transverse sections are almost identical. The greater irregularity in distribution of openings at the surface and the presence of megacanthopores and their enlargement exteriorly so as to resemble mesopores or zooecia are distinguishing features of our species.

Suborder CRYPTOSTOMATA Ulrich

Family FENESTELLIDAE King

Genus FENESTELLA Lonsdale

FENESTELLA BINODATA Condra

Plate 2, fig. 13

1902. *Fenestella binodata* CONDRA, Am. Geologist, vol. 30, no. 6, p. 350.
1903. *Fenestella binodata* CONDRA, Nebr. Geol. Surv., Bull. 2, p. 66, pl. 10, figs. 12, 13. Pennsylvanian, South Bend, Louisville, Cedar Creek, Weeping Water, Nebraska.

Our collection contains several well preserved specimens which appear assignable to Condra's species, the chief character of which is a broad rounded carina with an alternating double row of rather compressed more or less prominent nodes. In our specimens the branches are straight, about .35 mm. wide and nearly as deep, eight to eight and one half branches occurring in 5 mm.[1] Fenestrules .6 by .3 mm., six and one half to seven occurring in 5 mm., rather elongate subrectangular, the margins inflected by the lateral rows of zooecia. Dissepiments slightly expanded terminally and marked on the obverse by distinct striae, not depressed on the reverse, .1 to .15 mm. wide. The zooecia are located in alternate rows at the edges of the branch, about 20 in 5 mm. The apertures are circular with thin peristomes, prominent except on the side toward the carina. Each branch bears a broad bluntly rounded carina, carrying a double row of alternating nodes which are conical or compressed and somewhat obliquely directed. The reverse side of branches and dissepiments is

[1] In recording measurements of branches, fenestrules and zooecial apertures in this and all other fenestelloid bryozoans here described, the numbers of these in a given space indicate complete "units": that is, with each branch the adjacent fenestrule is included, measuring transversely; with each fenestrule is an adjoining dissepiment, measuring longitudinally; and with each zooecial aperture is an interspace. This method of designation has several advantages, especially in permitting ready conversion of any actual measurement to the selected unit of comparison.

striated. In its measurements and rather distinct surface features *F. binodata* is not readily confused with any other Pennsylvanian fenestelloid.

FENESTELLA SPINACRISTATA Moore, n. sp.

Plate 2, figs. 14-17

A rather common and distinctive species in our collection is a robust fenestelloid with unusually well developed, somewhat flattened spines along the keel. The branches are moderately stout, .45 to .55 mm. in width and about the same in thickness, straight to slightly flexuous, 6.5 to 7 in 5 mm. Fenestrules subrectangular, about 1.35 to .35 mm. in average length and width, 3.5 to 4.5 occurring in 5 mm. The lateral margins are only slightly indented if at all by the zooecia. Dissepiments a little less than half the width of the branches, .21 to .24 mm. in width, expanded only very slightly terminally and only slightly depressed on obverse and reverse faces. Zooecia in two alternating rows on each branch, 14 to 16 occurring in 5 mm. Apertures circular, .12 mm. in diameter and surrounded by a peristome which is most elevated on the outside of the branch. The apertures are slightly over twice their diameters apart. On the obverse side of the branches is a prominent rounded keel, one-third to nearly one-half the width of the branches, .18 to .24 mm. in width. The keel bears a series of prominent, laterally compressed spines, averaging when complete about .45 mm. in height and .3 to .45 mm in length of base along the keel. The axis of the spines is nearly vertical to the plane of the branch in some cases, but distinctly inclined at an angle of about 75 degrees, the apex of the spine being tilted forward in the direction of the zoarial growth. In some specimens the spacing of the spines is uniformly about .7 mm. but in others, chiefly in the vicinity of bifurcations of the branch, the interval ranges from .5 to .9 mm. An average of six or seven spines occur in 5 mm. The reverse side of branches and dissepiments are rather narrowly rounded and smooth.

F. spinacristata is perhaps more like *F. dentata* Rogers than other described Pennsylvanian species. *F. dentata* has slightly smaller and more closely spaced branches and fenestrules and more closely spaced zooecia. Its prominent, laterally compressed spines strongly resemble those of *F. spinacristata* but are very much more crowded, twelve appearing in 5 mm. In *F. kansasensis* Rogers, a less robust species, the spacing of the spines is more like that of *F. spinacristata*, but they are somewhat closer and less prominent and there are other specific differences.

FENESTELLA MIMICA var. TEXANA Moore, n. var.

Plate 2, figs. 18-22

A common fenestellid in the Wayland shale is very closely related to *F. mimica* Ulrich from the Pennsylvanian at Seville, Illinois. Ulrich's description is as follows: "Zoarium a small foliar expansion, branches rather slender, rigid, about .25 mm. in width and 7 in 3 mm. (Ulrich's figures show 13 in 5 mm.) Dissepiments short, about one-third as wide as the branches. Fenestrules subquadrangular, strongly concave at the side, .35 to .2 mm. and 7 in 3 mm. (11 to 11.7 in 5 mm.) Carina a very fine and but little projecting line bearing a row of small spines about .12 mm. apart. Zooecia in two ranges, 24 in 5 mm. Apertures large, circular with well developed peristome, slightly more than their diameter apart, generally two to each fenestrule so arranged that one is opposite each dissepiment and one between."

The measurements of our specimens are in every particular practically identical with these except that the spines along the median portion of the branches are regularly .19 mm. apart, the maximum range being .18 to .20 mm., and there are 23 zooecia in 5 mm. The reverse side of the zoarium, evidently not seen in Ulrich's specimens, is faintly to distinctly granulo-striated.

The distinguishing characters of *F. mimica* as compared to the closely related forms *F. tenax* Ulrich, *F. limbata* Foerste, and *F. cyclofenestrata* Condra are mainly in the shape of the fenestrules and the ill developed keel. *F. tenax* of the Mississippian has slightly larger and more elliptical fenestrules, larger cell apertures, and a distinct, strong keel. *F. limbata* has slightly narrower fenestrules, a distinct more or less wide keel with blunt spines .21 mm. apart. *F. cyclofenestrata* has wider dissepiments, subcircular fenestrules, and is without observed spines along the keel. As judged by measurements and comparisons with Ulrich's figures our specimens differ from *F. mimica* in the wider spacing of the spines along the ill defined carina and the slightly wider spacing of the zooecial apertures.

FENESTELLA PLACIDA Moore, n. sp.

Plate 2, figs. 5-7

Several fragments of this fenestellid, distinguished by large fenestrules and comparative simplicity of form, are contained in our collections. The branches are straight to slightly flexuous, .35 to .4 mm. in width by about .37 in maximum thickness, the obverse side sloping gently and evenly from a narrow median keel, .055 to .085

mm. wide, lateral margins of branches sharp and not distinctly indented by zooecia, reverse sides gently rounded, very finely granulose and more or less coarsely striated longitudinally. Five branches occur in 5 mm. The fenestrules are 1.4 to 1.6 in length by .4 to .63 mm. in width, the average being 1.5 by .6 mm. Distal widening of the dissepiments gives a distinctly elongate-ovate outline to the fenestrules. There are 3.0 to 3.2 fenestrules in 5 mm. The narrow part of the dissepiments ranges from .06 to .1 mm. in width; they are more or less coarsely striated. The zooecia are disposed in alternating rows on each branch, five to the fenestrule, and 15 to 16 in 5 mm. The round apertures, .1 mm. in diameter, are surrounded by a faint but distinct peristome. Well preserved specimens show the narrow median keel minutely granulose, and at intervals of .45 to 1.5 mm. bearing low nodes or spines, the average distance between the spines being 1 mm. The maximum observed height of spine is .15 mm.

Fenestella placida agrees approximately in its measurements with *F. polyporoides* Condra and *F. delicatula* Ulrich. From the first species ours is distinguished by its narrower keel, more widely spaced nodes and zooecia, and by the absence of a *Polypora*-like arrangement of zooecial rows near the bifurcation of branches. From the second species *F. placida* is distinguished by its more regular growth, thicker branches with zooecia not indenting the margins, its shorter and relatively thicker dissepiments and the rounded nature of the fenestrules. The species is readily differentiated from all of the others in our collection.

FENESTELLA PECTINIS Moore, n. sp.

Plate 2, figs. 8-10

A number of free specimens, the largest about 3 mm. square, exhibit characters which differentiate them from others in our collection and from described species. The branches are straight, about .25 mm. in width, ten and one half to eleven occurring in 5 mm. Fenestrules .3 to .35 long by .2 wide, quadrate to rectangular, ten occurring in 5 mm. The dissepiments are less than half the width of the branches, measuring about .1 mm. and are only very slightly expanded terminally. The zooecia are somewhat unevenly arranged in two alternating rows, an aperture commonly being located at each end of the dissepiment, and one at the mid-length of the fenestrule, 23 occurring in 5 mm. Apertures circular, .075 mm. in diameter, bearing a peristome which is rather prominently elevated on the outside of the branch and, where well preserved, terminating in

a spinose projection. Each branch bears a moderately strong rounded carina about one-third the width of the branch. Along the carina is a single row of rather prominent conical or slightly compressed tubercles, .1 mm in diameter at the base and .2 mm. from one to the next, 25 to 26 in 5 mm. The spines rise about .12 mm. above the top of the keel. The reverse side of the zoarium is distinctly but finely granulose, the dissepiments not depressed below the branches.

Among previously described species *F. pectinis* is probably nearest to *F. spinulosa* Condra, which agrees approximately in size of branches and fenestrules and the spinulose character of the keel, but is slightly coarser, has closer spaced zooecia, and fewer spines, only 14 or 15 in 5 mm. *F. perelegans* Meek has more widely spaced zooecia, narrower dissepiments which are strongly depressed on the reverse side, and the reverse of the branches is striated. *F. conradi* Ulrich agrees in general measurement as to number of branches, fenestrules, and zooecia, but has smaller fenestrules, much thicker dissepiments, and more widely spaced spines.

FENESTELLA PLUMMERAE Moore, n. sp.

Plate 2, figs. 11, 12

The holotype of this species is a fragment 4 by 3 mm. The branches are straight with rather frequent bifurcation as judged from the specimen in hand; width of branches .25 mm., eleven to twelve occur in 5 mm. Fenestrules subquadrate about .4 by .3 mm., eleven occurring in 5 mm. The terminal enlargement of the dissepiments and the strong projection of a zooecium on each side of the fenestrule gives its outline, as seen from the obverse side a distinct figure 8 shape, but on the reverse a straight dissepiment practically without terminal enlargements emphasize the quadrate form. The dissepiments are a little less than half the width of the branches, even with them on the reverse but slightly depressed on the obverse, bearing on this side distinct striae or furrows. The zooecial apertures are located at the end of the dissepiments and one on each side of the fenestrules midway between the dissepiments. There are 21 or 22 zooecia in 5 mm. The apertures are circular, .07 mm. in diameter and are surrounded by an elevated peristome. A broad bluntly rounded carina, .12 mm. in width, occurs on the obverse side of each branch. A slightly staggered row of small tubercles is situated on top of the keel, one spine being located obliquely above each aperture making the number of tubercles equal to that of the zooecia on

each branch, or twice that of a single row of zooecia. The reverse side of the zoarium is somewhat coarsely granulose.

This species is most closely related to *F. mimica* Ulrich, which agrees approximately in spacing of branches and fenestrules and to a certain extent in the position of the apertures with reference to the end of the dissepiments and the sides of fenestrules. The branches, however, in *F. mimica* are relatively wider, the fenestrules smaller and little indented by the marginal zooecia. Our species has a slightly smaller number of zooecia in a given space and an entirely different keel and tubercle. The latter suggests *F. binodata* Condra, a much coarser form which can not be confused. The species is named in honor of our friend, Mrs. Helen Jeanne Plummer, capable and enthusiastic micro-paleontologist, of Austin, Texas.

FENESTELLA SPINULIFERA Moore, n. sp.

Plate 3, figs. 3-5

This species is distinguished by the rather strongly spinulose character of the reverse side of the zoarium, both the dissepiments and the somewhat coarsely striated reverse side of the branches bearing numerous small pustules and short sharp spinules.

Branches about .32 mm. in width, six and one-half to eight occurring in 5 mm. Fenestrules subquadrangular, .6 mm. in length by .3 to .4 mm. in width, six to eight occurring in 5 mm. Although there is a slight variation in the spacing of branches and fenestrules in different specimens, in each the number of branches in a given space accord almost exactly with the number of fenestrules in the same space. Dissepiments thin, about .1 mm. in width, slightly expanded distally. Zooecia in alternating rows, four to each fenestrule and 22 to 24 in 5 mm. Apertures directed obliquely outward so that from above they appear somewhat elliptical, surrounded by a strong circular peristome, diameter .1 mm. inside the peristome. The space between the apertures is slightly less than the width of the apertures. A distinct keel .09 mm in width bears short but distinct laterally compressed spines at intervals of .31 to .34 mm.

F. spinulifera is most closely like *F. modesta* Ulrich from which it is distinguished by spacing of branches and fenestrules, by the slightly larger and more closely crowded zooecia and spines, and the spinulose character of the reverse side.

FENESTELLA SPINULIFERA var. PUSTULOSA Moore, n. var.

Plate 3, figs. 1, 2, 6

This variety is distinguished by its slightly narrower branches which are more closely spaced than the fenestrules, smaller zooecia which are more than their diameter apart, and the occurrence of irregularly scattered large pustules on the reverse side. Measurements of the figured specimens are: branches .22 mm. in width, nine in 5 mm., fenestrules .6 by .? mm., seven in 5 mm.; zooecia .085 mm. in diameter, 23 in 5 mm.; spines on carina .34 mm. apart.

FENESTELLA MODESTA Ulrich

Plate 3, figs. 12, 13

1890. *Fenestella modesta* ULRICH, Geol. Surv. Illinois, vol. VIII, p. 550, pl. LII, figs. 3-3 *b*. Coal Measures, Knox County and Seville, Ill.

A few specimens possessing the measurements and the more or less distinctive characters of *Fenestella modesta* are found in our material. One of these shows the branches .3 mm. in width, 7.7 in 5 mm.; fenestrules .77 by .43 mm., subquadrangular to elongate-ovate, 5.8 in 5 mm.; dissepiments slender, about 1 mm. in width at the center, expanded distally, more or less strongly striated; zooecia with circular or sub-pyriform apertures, .09 mm. in diameter, surrounded by thin elevated peristome, 21 in 5 mm. The branches bear a slender not very well defined median keel on which are low spines spaced .4 mm. apart. The reverse side is rather strongly granulo-striated.

The characters described in our specimens are practically identical with those given by Ulrich for the type from Illinois. The measurements and surface characters rather clearly distinguish this species from other Pennsylvanian forms.

FENESTELLA MODESTA Ulrich, var.

Plate 3, fig. 11

Several small bryozoan fragments from the Wayland shale appear more closely related to *F. modesta* Ulrich than to other described species. They differ mainly in the slightly smaller fenestrules and wider spacing of the zooecia. Eight to eight and one-half branches and seven to eight and one-half fenestrules occur in 5 mm. The number of zooecia in 5 mm. is rather constantly about 19, whereas typical *F. modesta* has 20 to 21. The small spines along the thin median keel

are .4 to .45 mm. apart as in typical examples of Ulrich's species. The reverse side is rather strongly granulo-striated.

Some specimens of *F. spinulosa* Condra have measurements agreeing with our specimens but are readily distinguished by the less delicate character of the zoarium and by the closer spacing of the spines on the rather stout carina.

FENESTELLA GRATIOSA Moore, n. sp.

Plate 3, figs. 14-16

The holotype is a well preserved specimen measuring 5 mm. by 2 mm., branches straight or curving gently, with bifurcations from 1.2 to 2.5 or more mm. apart long branches. Width of branches below bifurcation .25 and above .2 mm., 11½ to 12 occurring in 5 mm. Fenestrules about .45 by .21 mm., well rounded at the ends and somewhat indented in the middle by projecting zooecia so that the shape of the opening is roughly like that of a moccasined footprint. The

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EXPLANATION OF PLATES

PLATE 3

FIGS. 1, 2, 6.—*Fenestella spinulifera* var. *pustulosa* Moore, n. var. 1, reverse view of the type, ×10; 2, obverse view of this specimen, ×10; 6, a portion of the obverse, ×25.

3–5.—*Fenestella spinulifera* Moore, n. sp. 3, obverse view of a cotype, ×10; 4, reverse side of this specimen, ×10; 5, a portion of the obverse side, ×25.

7, 8, 20.—*Polypora elliptica* Rogers. 7, obverse side of a typical specimen, ×10; 8, reverse side of this specimen, ×10; 20, portion of the obverse side of specimen shown in fig. 7, ×25.

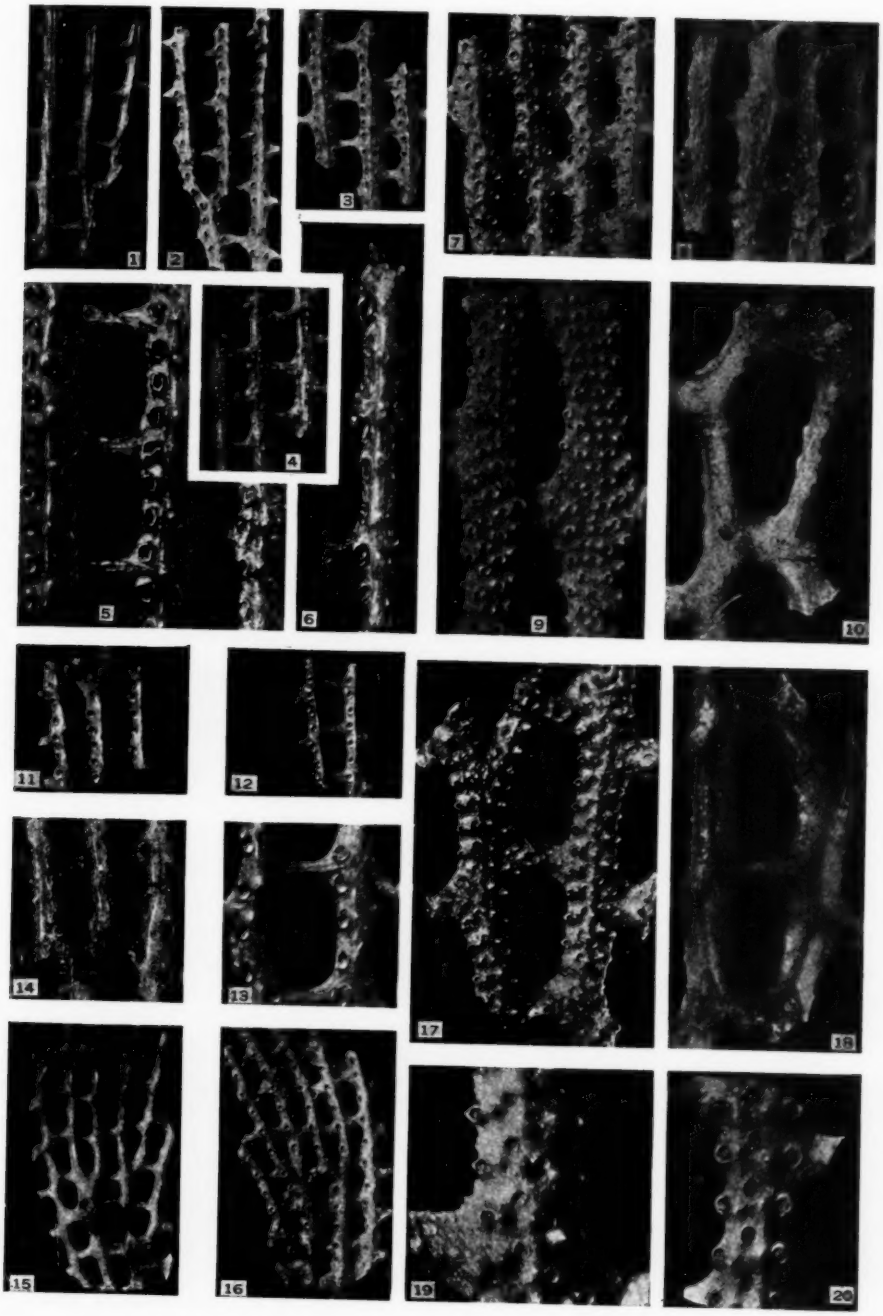
9, 10.—*Polypora aestacella* Moore, n. sp. 9, portion of the obverse side of the type, ×10; 10, portion of the reverse side of this specimen, ×10.

11.—*Fenestella modesta* Ulrich var. Obverse view of a fragment, ×10.

12, 13.—*Fenestella modesta* Ulrich. 12, obverse view of a fragment, ×10; 13, portion of this specimen, ×25.

14–16.—*Fenestella gratiosa* Moore, n. sp. 14, a portion of the obverse face of the type, ×25; 15, reverse side of the type, ×10; 16, obverse side of the type, ×10.

17–19.—*Polypora hirsuta* Moore, n. sp. 17, obverse side of a cotype, ×10; 18, reverse side of this specimen, ×10; 19, portion of the obverse side, ×25.



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number in 5 mm. measures 8.3. The dissepiments are moderately thick, .15 mm. in width, expanded at the points of junction with the branches, only slightly depressed. The zooecia are arranged in alternating rows, one occurring at the end of each dissepiment and one at the mid-length of the fenestrule, 16 occurring in 5 mm. The apertures are subcircular to pyriform in outline, .055 to .06 mm. in diameter. On the wider branches in the lower part of the specimen is a low rounded keel, .11 mm. in width, but on other parts of the zoarium the keel is very indistinct and except for faint granules is smooth. The reverse side of the branches is practically smooth, but in places faint longitudinal striations may be detected. At two points are the broken ends of the downward projection root by means of which the zoarium was presumably in part supported. The measurements and general characters of this species are unlike any known Carboniferous form.

Genus POLYPORA McCoy

POLYPORA ELLIPTICA Rogers

Plate 3, figs. 7, 8, 20

1900. *Polypora elliptica* ROGERS, Kans. University Quar., vol. 9, p. 7, pl. 4, fig. 2.

1903. *Polypora elliptica* CONDRA, Nebr. Geol. Surv. Bull. 2, pt. 1, p. 69, pl. 11, figs. 4-11; pl. 12, figs. 1-13; pl. 16, fig. 3.

Numerous specimens readily separable from others in our collections show typically the characters assigned to *Polypora elliptica* Rogers. Our forms seem to accord more closely with the types described by Rogers rather than the majority of those regarded by Condra as representatives of the species.

The branches are straight or very slightly flexuous, .4 to .5 mm. wide, 12 to 14 in 10 mm. The obverse face is gently convex, and the development of a low ridge and nodes between the rows of zooecia produces a more or less faceted appearance. The reverse side of the branches is broadly to somewhat narrowly rounded, and bears rather strong, even, longitudinal striae. The thickness of the branches is commonly less than the width. The dissepiments average about .3 mm. in width, which is rather more than half the width of the branches. They are distended terminally so as to give to the fenestrules a distinctly elliptical outline, and on both sides of the zoarium they are even or only slightly depressed below the surface of the branches. The fenestrules measure typically .9 by .35 mm.,

eight to eight and one-half fenestrules in 10 mm. In the majority of our specimens the margins of the fenestrules are slightly indented by the projecting peristomes of the outer ranges of zooecia. The zooecia occur typically in three rows, the apertures being alternately spaced so as to make rather regular oblique cross rows; where a branch widens before bifurcation as many as five rows of zooecia may appear, while immediately beyond the bifurcation there may be but two rows. The circular apertures, .1 mm. in diameter, are surrounded by a thin but distinct peristome, barely elevated above the surface of the branch in the median row, but rather strongly raised on the lateral rows, the side toward the adjacent fenestrule commonly bearing a spine-like projection. The apertures are separated from one another by about one and one-half to two times their diameter, 15 occurring in the space of 5 mm. Between the rows of zooecia are distinct but not elevated ridges which in well preserved specimens show low nodes that are spaced at the same interval as the zooecia.

The measurements and surface characters described in the Texas specimens are essentially constant and agree very closely with Roger's original figure and description. *P. spinulifera* Ulrich and *P. whitei* Ulrich are somewhat similar to *P. elliptica,* but commonly have a larger number of fenestrules and zooecia in a given space and differ in surface character. This form is distinct from all of the other species of *Polypora* found in our collection, by reason of its delicate size and surface markings.

POLYPORA AESTACELLA Moore, n. sp.

Plate 3, figs. 9, 10

This moderately distinctive species is characterized by robust, straight, or slightly flexuous branches, .75 to 1.0 mm. wide, .85 to 1.0 mm. in thickness, six to seven and a half branches occurring in 10 mm. The obverse side is very gently convex to nearly flat, the reverse side shows flat or slightly concave sides and a somewhat narrowly rounded median portion. The obverse side is finely granulose, the reverse smooth except for very faint granules along the crest. The dissepiments, very slightly depressed on the obverse but even with the branches on the reverse, range in width from .45 to .9 mm. The fenestrules are elongate-ovate in outline, 2.1 to 2.7 mm. in length by 6.5 to 7.5 mm. in width. Three or four fenestrules occur in 10 mm. The zooecia are rather regularly arranged in alternating rows so that oblique and transverse series as well as longitudinal rows appear. Four to six longitudinal rows appear on each branch; eleven

to twelve zooecia occur in 5 mm. longitudinally; diagonally the apertures are about .3 mm. apart, transversely about .35 mm. The outside rows of zooecia are more strongly elevated than the inner ones and project distinctly so as to indent the margins of the fenestrules, five to six zooecia occurring in each row to the fenestrule. The apertures, .085 mm. in diameter, are surrounded by a distinct, more or less elevated peristome which is complete except on the posterior or proximal side, where, accordingly, there is a distinct indentation. This is accentuated by the development on each side of the peristome and nearly on opposite sides of the zooecial apertures, of low spines or tumid swellings. In the type specimens these node-like swellings gave a transverse corrugation to the branches.

In general measurements *P. aestacella* agrees most closely with *P. remota* Condra and *P. triangularis* Rogers. The first of these is distinguished from our species by its thin narrow dissepiments, by the complete peristomes and lack of spinose projections on the obverse face. *P. triangularis* is distinguished by the sharply angular median portion of the branches on the reverse side bearing a row of more or less prominent nodes, by its narrow long dissepiments, wider fenestrules, and slightly more closely crowded zooecia. *P. distincta* Ulrich is a less regular species with generally longer fenestrules and is without distinct nodes or incomplete peristomes.

POLYPORA HIRSUTA Moore, n. sp.

Plate 3, figs. 17-19

Several well preserved fragments consisting of two or three branches and as many fenestrules that are contained in our collections, appear to represent a species not previously described. Its most noteworthy character aside from the measurements of branches, fenestrules and zooecia, is the occurrence of rows of prominent spines and the elevated peristomes of the zooecia, particularly of the outer ranges.

The branches are straight and rather markedly sub-parallel, .65 to .8 mm. in width, and 6 to 6½ occurring in the space of 10 mm. The obverse side is distinctly but gently arched, the lateral margins sharply angulated, and the reverse side marked by two smooth, steeply inclined plane or slightly concave slopes forming an angle of about 90 degrees and meeting in a rounded, rather narrow crest. The cross section of the branch is comparable to the quadrant of a circle. The dissepiments are slightly more than half the width of the branches, measurements ranging from .45 to .65. On the obverse

side they are slightly depressed below the high part of the branches, but on the reverse side they are essentially even with the branches. Many of them carry an enlarged zooecial opening apparently representing an ovicell. The fenestrules are elongate-ovate in outline and as seen from above the margins are slightly indented by the projecting somewhat spiniform peristomes of the lateral ranges of zooecia. The average length of the fenestrules is 1.5 mm., the width .75 mm. About 4½ fenestrules occur in a space of 10 mm. The zooecia are disposed in four to five alternating rows. The round aperture, measuring .085 in diameter, is surrounded by a distinct peristome, which on the outer rows of each branch is markedly elevated on the outside edge into a spine-like crest. These outer zooecia thus stand prominently above the general surface of the zoarium. Fourteen to sixteen zooecia occur in 5 mm., the interzooecial spaces longitudinally being about twice the diameter of the apertures. Between the rows of zooecia are rows of more or less prominent nodes or spines, their spacing corresponding closely to that of the zooecia. They are so disposed with reference to the zooecia that oblique cross rows as well as longitudinal rows are formed. In some cases the median row of spines is more prominent than in others, being raised slightly along a sort of low keel. The arrangement of zooecia and spines suggests the association of zooecia and strong acanthopores which is seen in *Rhombopora* and certain other Cryptostomata, but the internal structure as revealed by grinding does not show recognizable acanthopores. The superior hemiseptum is unusually strong, even in the central part behind the primary aperture. The reverse face of the zoarium is smooth. Some of the dissepiments show openings of accessory pores approximately the size of the zooecial apertures. Sections of the branches show a thick deposit of sclerenchyme along the reverse side, beneath the zooecia.

P. hirsuta resembles *P. submarginata* Meek more closely than any other species. The spacing of fenestrules and branches corresponds almost exactly, and the obverse of both forms is spinose. *P. submarginata* differs in having a larger number of rows of zooecia, 5 to 8, in the more sharply carinate lateral margins which suggested the name of this species, and in the distribution of the tubercles. Meek's figures show a specially strong central row of nodes which are much more closely spaced than in our specimens; the outer parts of the branches lack distinct nodes. *P. nodocarinata* Ulrich differs in the smaller size of the branches and fenestrules and in the much closer spacing of the zooecia. *P. anastomosa* Mather which corresponds in

the spacing of branches and fenestrules differs in the much smaller and rounded character of the fenestrules, and much wider dissepiments and in other characters. *P. aspera* Rogers is similar in the spacing of fenestrules and in its rough surface, but has more closely spaced branches of irregular form, and the zooecia are more closely spaced and pyriform.

(TO BE CONTINUED)

A NOTE ON THE NAMES CYCLOSIPHON EHRENBERG, 1856, AND LEPIDOCYCLINA GÜMBEL, 1868

By THOMAS WAYLAND VAUGHAN
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The question has recently been raised as to whether the generic name *Cyclosiphon* Ehrenberg or *Lepidocyclina* Gümbel should be applied to the genus of larger foraminifera of which *Nummulites mantelli* Morton is the geno-type.

Ehrenberg (p. 145) places *Cyclosiphon* and *"Orbitoides"* under his Helicosorinen, which he defines as follows:

Helicosorinen. Deutlicher Sipho. Quadratische oder rundliche Kammern. Abgeschlossene Canäle der Schale.

The two genera are defined as follows:

Cyclosiphon. Kammern rundlich ohne Lateral-Loben, in einfacher Reihe concentrisch, mit dünnen einfachen oder undeutlich zelligen Uberzug, mit Sipho und verästeten, abgeschlossenen Canalsystem in der dünnen Schale.=*Nummulites Mantelli.*

Orbitoides. Kammern quadratisch. ohne Lateral-Loben, in einfacher Reihe mitten zwischen 2 verschiedenartigen Zellschichten und einem abgeschlossenen, verästeten Canalsystem in denselben.

Die mittelste Anfangskammer ist stets verhältnissmässig gross, von unregelmässiger Spiralform in kleinere Kammern übergehend, die dann eine mehr oder weniger kurz- oder langquadratische Gestalt annehmen, bedingt durch meist 4, je 2, Verbindungscanäle. Unregelmässige Spirale. Scheibe spaltbar.

Except Professor J. J. Galloway, authors of date more recent than Gümbel, who have divided into genera and subgenera the old agglomeration that was placed under *"Orbitoides"* have not used the name *Cyclosiphon.* Professor Galloway (p. 64) contends that *Cyclosiphon* should replace *Lepidocyclina.*

Since *Nummulites mantelli* is the only species mentioned under *Cyclosiphon,* it would appear that the genus is monotypic and that that would settle the case, but the matter is not quite so simple.

Ehrenberg says regarding the chambers of Cyclosiphon, "mit dünnen einfachen oder undeutlich zelligen Überzug", and he says regarding those of what he called "Orbitoides", "in einfacher Reihe mitten zwischen 2 verschiedenartigen Zellschichten". The *"Orbitoides"* of Ehrenberg is *Discocyclina* Gümbel. An important distinction between *Cyclosiphon* and the *"Orbitoides"* of Ehrenberg is that the former possesses no or only indistinct lateral chambers, whereas the latter possesses well developed lateral chambers. *Nummulites mantelli* possesses well developed lateral chambers which enclose a medianly situated equatorial layer. Therefore, *Nummulites mantelli*, according to the original definition of *Cyclosiphon* does not belong to that genus, notwithstanding Ehrenberg's mention of it. Shall we accept as the type-species of a genus, a species which by the definition of that genus is excluded from that genus?

Dr. J. A. Cushman has written me that while in Berlin he examined the specimens marked *Cyclosiphon* in Ehrenberg's collection and that he "found them to be glauconitic casts, some of which were evidently *Textularia*, others perhaps *Discocyclina*, very few, if any, that could be considered as *Lepidocyclina*, and that surely no one could tell from the fragments specific characters".

Gümbel (p. 689) defines *Lepidocyclina* and characterizes *L. mantelli* as follows:

Subgenus LEPIDOCYCLINA

Gehäuse flachlinsen—oder dünnscheibenförmig mit rundlich begrenzten Mediankammern.

(1) *L. Mantelli* Morton spec.; gross, flach, linsenformig, mit sehr zahlreichen, nicht grossen Mediankammern und mit nicht ser zahlreichen Lateralkammern. Oberfläche fast glatt.

This is perfectly clear to any one who has had personal experience with these organisms. Because of confusion surrounding *Cyclosiphon*, it appears to me undesirable, even unfortunate, to revive that name, and it seems that the use of the name *Lepidocyclina*, with *Nummulites mantelli* as the type-species of both the genus and the typical subgenus, should be continued.

LITERATURE CITED

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Galloway, J. J., A revision of the Family Orbitoididae: Jour. Pal., vol. 2, p. 64, 1928.

Gümbel, C. W., Beiträge zur Foraminiferenfauna der nordalpinen Eocängebilde: K. bay. Ak. Wissensch., Cl. VI, Bd. 10, p. 689, 1868.

SOME INDEX FORAMINIFERA OF THE TAMPICO EMBAYMENT AREA OF MEXICO[1]

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PART III

SYSTEMATIC PART CONTINUED

Family TEXTULARIIDAE d'Orbigny, 1846

Genus TEXTULARIA Defrance, 1824

Genotype (monotypic) *T. sagittula* DEFRANCE, Dict. Sci. Nat., vol. 32, 1824, p. 177; vol. 53, 1828, p. 344; vol. 12, pl. 13, fig. 5. (Pliocene, Castel-Arquato, Italy.)

Description.—Test free, elongate, tapering, composed of two series of alternating chambers, sometimes with a small, planispiral coil in the nepionic stage of the microspheric form; test typically flattened on the biserial side and angled on the two edges, but sometimes oval or round in section; chambers numerous, usually closely appressed, the later ones sometimes inflated; wall agglutinated, coarsely to finely arenaceous, with much calcareous cement, and sometimes with a calcareous early stage, at other times with a calcareous inner wall; aperture single, semilunar, at the base of the last chamber, sometimes with raised margin, or circular.

TEXTULARIA EXCOLATA Cushman

Plate 4, fig. 1

Textularia excolata CUSHMAN, Bull. Amer. Assoc. Petr. Geol., vol. 10, no. 6, 1926, p. 585, pl. 15, fig. 9.

[1] The last of three parts.

Description.—Test broad as long, the sides flattened or somewhat convex; periphery, of early portion at least, acute; chambers few, the sides somewhat concave; sutures distinct due to the thickening of the peripheral edge, the surface below being somewhat concave; wall smoothly finished.

Height of figured specimen, 0.4 mm.; width, 0.5 mm.; thickness at the apertural end, 0.3 mm.

Occurrence.—This species occurs as a common form in the base of the Velasco, becoming rare before reaching the middle and extending past the limit of that formation as treated here.

The figured specimen is from locality No. 10.

TEXTULARIA NACATAENSIS, n. sp.

Plate 4, fig. 2

Textularia cf. conulus, BEISSEL (not REUSS), Abh. K. Preuss. Geol. Landesanstalt N. F., vol. 3, 1891, p. 68, pl. 13, figs. 23-29.

Description.—Test conical, rounded, flat on top; sutures practically flush and somewhat indistinct; chambers low and flat; wall finely arenaceous; aperture semilunar, at the base of the last chamber.

Height of type specimen, 0.7 mm.; greatest diameter, 0.57 mm.

Holotype.—Columbia University Paleo. Coll. No. 19917, from locality No. 3.

Occurrence.—This species occurs as a rare form from the base of the upper portion of the Papagallos into the lower portion of the Velasco.

This species may be a *Textulariella*, but none of the specimens show the radial septa.

TEXTULARIA NACATAENSIS var. CYCLOSTOMA, n. var.

Plate 4, fig. 3

Description.—This variety of the species is similar to the preceding except that the aperture is circular and a short distance from the base of the last chamber; the test is generally larger and the sutures more distinct, being slightly depressed.

Height of type specimen, 0.9 mm.; greatest diameter, 0.7 mm.

Holotype.—Columbia University Paleo. Coll. No. 19918, from locality No. 30.

Occurrence.—This variety of the species is a very rare form through a very restricted vertical range in the middle portion of the Velasco.

The type of aperture possessed by this form is that which tends to develop in the advanced stages of species of this genus as well as in *Gaudryina* and other forms.

TEXTULARIA, sp?

Plate 4, fig. 4

Description.—This is always a very much crushed and flattened form which has been replaced by silica; test irregular, pointed; sutures obscured with only a suggestion of its biserial character in the earlier chambers, and in the indentations of the outline of the test as seen in side view; surface very rough; aperture obscured.

Height of figured specimen, 0.9 mm.; greatest width, 0.4 mm.; thickness, 0.2 mm.

Occurrence.—This species occurs as a little better than rare form in the lower portion of the Velasco.

Another example of replacement by silica and having its structure so poorly preserved, it is probably best left as a questionable species, if not genus.

The figured specimen is from locality No. 15.

Family HETEROHELICIDAE Cushman, 1927

Genus SPIROPLECTOIDES Cushman, 1927

Genoholotype *Spiroplecta rosula* EHRENBERG, Mikrogeologie, 1854, pl. 32, II, fig. 26. (Upper Cretaceous, Mississippi Valley.)

Spiroplectoides CUSHMAN, Contrib. Cushman Lab. Foram. Res., vol. 2, pt. 4, 1927, p. 77.

Description.—Test free, flattened, elongate with nearly parallel sides; early chambers planispiral, in about one whorl, later chambers biserial; chambers numerous, closely appressed; wall calcareous, hyaline, finely perforate; aperture terminal, elongate or elliptical.

SPIROPLECTOIDES CLOTHO (Grzybowski)

Plate 4, fig. 5

Spiroplecta clotho GRZYBOWSKI, Rozprawy Akad. Umiejetnosci Wydzial Math.-Przyrodniczy, ser. 3, vol. 41, 1901, p. 283, pl. 7, fig. 18.

Spiroplectoides clotho CUSHMAN, Journ. Pal., vol. 1, no. 2, 1927, p. 159, pl. 28, fig. 6.

Textularia anceps (?) ELEY, Geol. in the Garden, 1859, p. 202, pl. 9, fig. 15C, p. 196, pl. 3, fig. 15.

Spiroplecta annectens CUSHMAN (not PARKER and JONES), Bull. Amer. Assoc. Petr. Geol., vol. 10, no. 6, 1926, p. 584, pl. 15, fig. 4.

Description.—Test flattened, sides roughly parallel, often pointed in the early portion with a circular spiral portion attached to the point; periphery acute; chambers broad and low; sutures distinct, almost flush, slightly limbate.

Length of figured specimen, 0.73 mm.; greatest width, 0.35 mm.; thickness, 0.12 mm.

Occurrence.—This species occurs as a fairly common form through the middle portion of the Mendez after which it gradually becomes rare, extending throughout that portion of the Velasco treated in this paper.

The figured specimen is from locality No. 34.

Genus PLANOGLOBULINA Cushman, 1927

Genoholotype *Gümbelina acervulinoides* EGGER, Abh. Math.-Phys. Cl. der König. Bay. Akad. Wiss., München, vol. 21, 1902, pl. 14, figs. 14-18, 20-22. (Upper Cretaceous, Bavarian Alps.)

Planoglobulina CUSHMAN, Contrib. Cushman Lab. Foram. Res., vol. 2, pt. 4, 1927, p. 77.

Description.—Test free, flabelliform; chambers numerous, subspherical, in the early stage of the microspheric form planispiral, in the megaspheric form biserial, and in the later stages the chambers are arranged in fan shape or even extending back toward the earlier chambers on either side, the later chambers in one plane; wall calcareous, finely perforate; aperture not definitely known.

PLANOGLOBULINA ACERVULINOIDES (Egger)

Plate 4, fig. 6

Gümbelina acervulinoides EGGER, Abh. Math.-Phys. Cl. der König. Bay. Akad. Wiss., München, vol. 21, 1902, p. 36, pl. 14, figs. 21, 22 only.

Pseudotextularia acervulinoides CUSHMAN, Contrib. Cushman Lab. Foram. Res., vol. 2, pt. 1, 1926, p. 17, pl. 2, fig. 5.

Planoglobulina acervulinoides THOMAS and RICE, Journ. Pal., vol. 1, no. 2, 1927, p. 143, text fig. 1, spec. 8.—CUSHMAN, ibid., p. 158, pl. 27, fig. 3.

Description.—The description of the genus is sufficient for the species.

Diameter of figured specimen, 0.6 mm.; thickness, 0.1 mm.

Occurrence.—This species occurs as a rare form throughout the Papagallos, becomes abundant just before reaching the Mendez and continues so through the lower portion of that formation.

The figured specimen is from locality No. 20.

Genus GÜMBELINA Egger, 1899

Genotype (designated by CUSHMAN, Contrib. Cushman Lab. Foram. Res., vol. 3, pt. 4, 1927, p. 190). *Textularia globulosa* EHRENBERG, Abh. k. Ak. Wiss. Berlin, Math.-Phys. Cl., 1838 (1840), p. 135, pl. 4, fig. 8. (Upper Cretaceous, Puszkary, Poland.)

Gümbelina EGGER, Abh. Math.-Phys. Cl. der König. Bay. Akad. Wiss., München, vol. 21, presented 1899, published 1902, p. 31, pl. 14, fig. 43.—CUSHMAN, Journ. Washington Ac. Sci., vol. 15, no. 6, 1925, p. 134. (Erroneously spelled "*Guembelina*".)

Pseudotextularia (part) RZEHAK, Ann. k. k. naturhist. Hofmus., vol. 10, 1895, p. 217, pl. 7, fig. 1, not figs. 2, 3, which is *Pseudotextularia varians* RZEHAK.—SCHUBERT, Jahrb. k. k. geol. Reichsanst., vol. 50, 1900 (1901), p. 660.

Textularia (part) of authors.

Description.—Test free, mostly minute, tapering, biserial; chambers globular, loosely or closely appressed; wall calcareous, hyaline, finely perforate, smooth or vertically striate; aperture at the base of the last chamber, semilunar.

GÜMBELINA EXCOLATA Cushman

Plate 4, fig. 7

Guembelina excolata CUSHMAN, Contrib. Cushman Lab. Foram. Res., vol. 2, pt. 1, 1926, p. 20, pl. 2, fig. 9; Journ. Pal., vol. 1, no. 2, 1927, p. 157, pl. 28, fig. 13.

Textularia costata CARSEY, U. Texas Bull. 2612, 1926, p. 26, pl. 1, fig. 4.

Description.—Test somewhat ovate, broad near the apertural end, pointed initial end, compressed; chambers slightly inflated, increasing in height as added; sutures only slightly depressed; wall ornamented with curved, longitudinal costae.

Height of figured specimen, 0.5 mm.; greatest width, 0.25 mm.; thickness, 0.1 mm.

Occurrence.—This species occurs as a rare form at the base of the upper portion of the Papagallos; is common in the uppermost beds of that formation and through the lower portion of the Mendez. It becomes an abundant species in the middle of the Mendez and dies out before the top of that formation is reached.

The figured specimen is from locality No. 3.

GÜMBELINA ELEGANS (Rzehak)

Plate 4, fig. 8

Cuneolina elegans RZEHAK, Ann. k. k. naturhist. Hofmus., vol. 6, 1891, pp. 3, 4, earlier called *Pseudotextularia* but not with any species name.

Pseudotextularia varians RZEHAK, Ann. k. k. naturhist. Hofmus., vol. 10, 1895, p. 217, pl. 7, fig. 1 only.

Pseudotextularia a PLUMMER, U. Texas Bull. 2644, 1927, p. 35, pl. 2, fig. 1.

Description.—Test flattened in a direction opposite to most forms of the genus, so that the broad side shows only one instead of the usual two series of chambers; shaped like a bellows; at least the early chambers of most specimens vertically striate; aperture unobserved.

Height of figured specimen, 0.9 mm.; width at apertural end, 0.7 mm.; thickness at apertural end, 0.35 mm.

Occurrence.—This species occurs as a rare form from the upper San Felipe into the base of the Papagallos, where it gradually becomes more common until it may be said to be common through the middle portion of the Papagallos. In the upper Papagallos it becomes abundant and remains so to the limit of its range at the top of the Mendez.

The large lunate space, filled with foreign material, shown at the base of the last chamber of the figured specimen, is probably the aperture.

The figured specimen is from locality No. 3.

GÜMBELINA GLOBIFERA (Reuss)

Plate 4, fig. 9

Textularia globifera REUSS, Sitz. K. Akad. Wiss. Math.-Nat. Cl. Wien, vol. 40, 1860, p. 232, pl. 13, figs. 7, 8.

Gümbelina globifera EGGER, Sitz. Math.-Phys. Cl. König. Bay. Akad. Wiss., München, 1909-1910, p. 22, pl. 2, fig. 16.

Guembelina globifera CHAPMAN, W. Australian G. S. Bull. 72, 1917, p. 20, pl. 2, fig. 18.

Description.—Test rather narrow V-shaped with sides very slightly curved; chambers slightly appressed, numerous; surface smooth; aperture a semilunar opening in the base of the last chamber.

Height of figured specimen, 0.6 mm.; greatest width, 0.35 mm.; greatest thickness, 0.23 mm.

Occurrence.—This species occurs as a rather common form from the middle of the San Felipe to the top of the middle portion of the Papagallos. From this point to the end of its range at the top of the Mendez it is abundant.

The figured specimen is from locality No. 1.

GÜMBELINA GLOBULOSA (Ehrenberg)

Plate 4, fig. 10

Textularia globulosa EHRENBERG, Abh. k. Ak. Wiss. Berlin, Math.-Phys. Cl., 1838 (1840), p. 135, pl. 4, fig. 8; Mikrogeologie, 1854, pl. 32, pt. 1, fig. 8, pl. 32, pt. 2, fig. 12.—ELEY, Geol. in the Garden, 1859, p 194, pl. 2, fig. 9, p. 202, pl. 9, fig. 9C.—WOODWARD and THOMAS, Geol. and Nat. Hist. Sur. Minn., vol. 3, pt. 1, 1885-92, p. 29, pl. C, fig. 6 only.

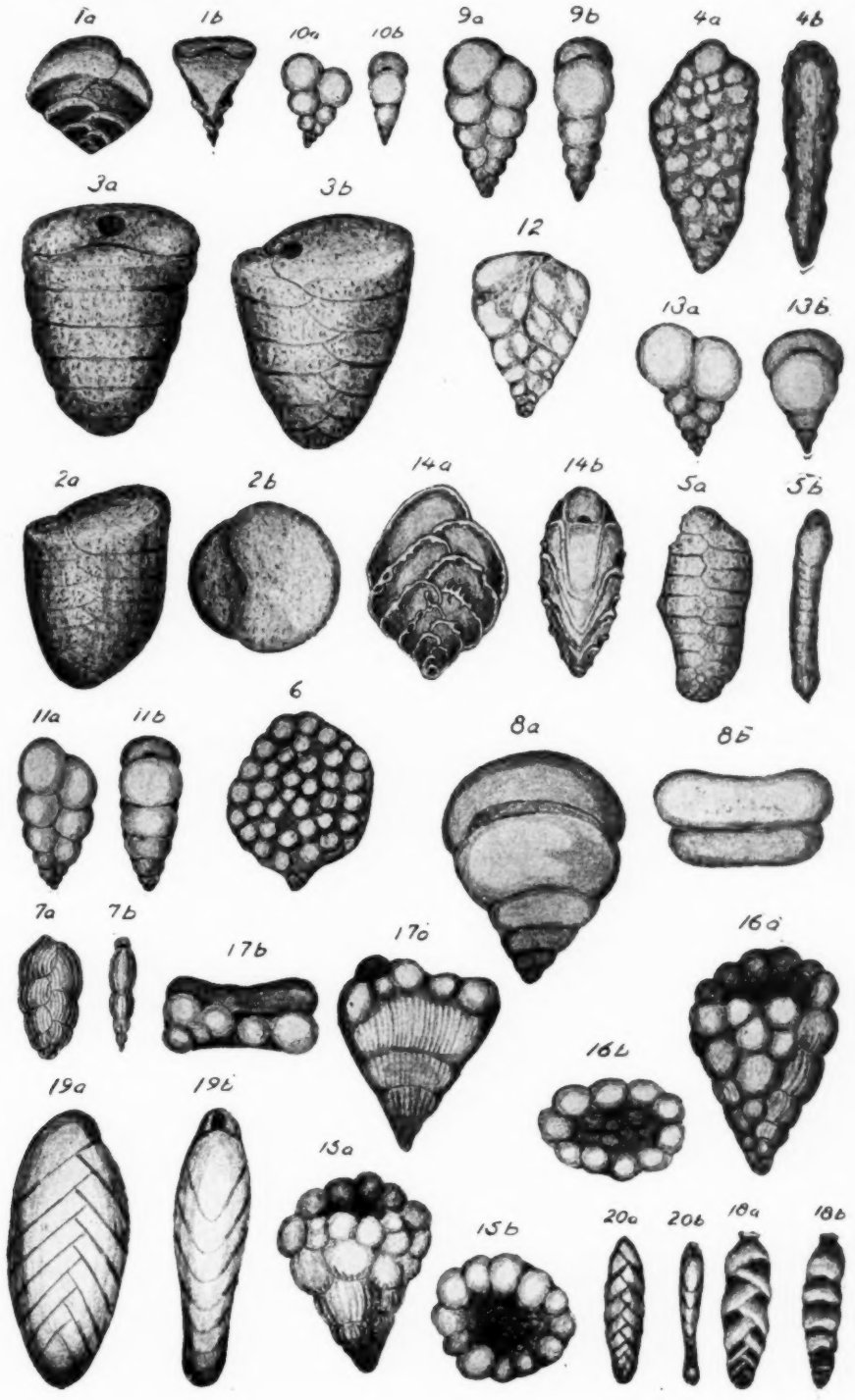
Description.—Test V-shaped, widening rather rapidly with straight sides to the V; chambers spherical, not appressed; surface smooth; aperture a semilunar opening at the base of the last chamber.

Height of figured specimen, 0.4 mm.; greatest width, 0.3 mm.; greatest thickness, 0.17 mm.

Occurrence.—This species occurs in two distinct forms, a normal and a dwarf. The latter differs from the former in being only a fraction of the size. The dwarf is abundant from the base of the San Felipe through the lower portion of the Velasco. The normal form is common at the very base of the San Felipe and rare from there to the uppermost beds of the Papagallos where it becomes abundant, remaining so through the lower portion of the Mendez.

EXPLANATION OF PLATE 4

FIG. 1.—*Textularia excolata*, ×40.
2.—*Textularia nacataensis*, ×40.
3.—*Textularia nacataensis* var. *cyclostoma*, ×40.
4.—*Textularia* sp?, ×40.
5.—*Spiroplectoides clotho*, ×40.
6.—*Planoglobulina acervulinoides*, ×40.
7.—*Gümbelina excolata*, ×40.
8.—*Gümbelina elegans*, ×40.
9.—*Gümbelina globifera*, ×40.
10.—*Gümbelina globulosa*, ×40.
11.—*Gümbelina pupa*, ×40.
12.—*Gümbelina* sp?, ×40.
13.—*Gümbelina ultimatumida*, ×40.
14.—*Gümbelina velascoensis*, ×40.
15.—*Pseudotextularia varians*, ×40.
16.—*Pseudotextularia varians* var. *mendezensis*, ×40.
17.—*Pseudotextularia varians* var. *textulariformis*, ×40.
18.—*Eouvigerina cretacea*, ×40.
19.—*Bolivina incrassata*, ×40.
20.—*Bolivina primatumida*, ×40.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18b

The normal form is common throughout the rest of the Mendez and for a very short distance in the base of the Velasco.

It has been rather hard to determine the proper name for certain of these forms. The separation of these last two species, especially from the literature, has bothered me. In solving the question I have included in *G. globulosa* the form in which the chambers are spherical, having suffered practically no appression; where the test is regular in its V shape and not slightly curved; where the broadening of the V is rather rapid and where the chambers are relatively few.

The figured specimen is a normal form from locality No. 16.

GÜMBELINA PUPA (Reuss)

Plate 4, fig. 11

Textularia pupa REUSS, Sitz. K. Akad. Wiss. Math.-Nat. Cl. Wien, vol. 40, 1860, p. 232, pl. 13, figs. 4, 5.—CUSHMAN, Bull. Amer. Assoc. Petr. Geol., vol. 10, no. 6, 1926, p. 584, pl. 15, figs. 5, 6.

Guembelina pupa CUSHMAN, Journ. Pal., vol. 1, no. 2, 1927, p. 157, pl. 27, fig. 6.

Description.—Test a curved V shape in outline; chambers appressed so that they are broader than high; aperture a lunate opening at the base of the last chamber.

Height of figured specimen, 0.6 mm.; greatest width, 0.3 mm.; greatest thickness, 0.25 mm.

Occurrence.—This species is a rare to common form from the upper Papagallos to about the middle of the Velasco.

The same characteristics that differentiate *G. globifera* from *G. globulosa*, carried to a further degree, differentiate this form from *G. globifera*.

The figured specimen is from locality No. 1.

GÜMBELINA, sp?

Plate 4, fig. 12

Description.—This is a very badly crushed and flattened form in which, due to the distortion, the later chambers and the character of the aperture are obscured.

Height of figured specimen, 0.6 mm;. greatest width, 0.45 mm.; thickness, 0.1 mm.

Occurrence.—This species occurs as a rare form principally in the uppermost beds of the Papagallos though it may be found all through the Mendez.

This form has suffered so much distortion as to make it advisable

to leave its specific identity in doubt, but as was the case with a similiarly crushed form among the *Globigerinas*, it has proved of some value in correlation and is included here for that reason.

The figured specimen is from locality No. 1.

GÜMBELINA ULTIMATUMIDA, n. sp.

Plate 4, fig. 13

Description.—Test V-shaped in outline; chambers spherical, the last two very much enlarged; wall sometimes very faintly striate in the early chambers; aperture a long lunate opening at the base of the last chamber.

Height of type specimen, 0.6 mm.; greatest width, 0.3 mm.; greatest thickness, 0.25 mm.

Holotype.—Columbia University Paleo. Coll. No. 19919, from locality No. 1.

Occurrence.—This species occurs as a common form from the base of the upper Papagallos throughout the Mendez and sometimes in the base of the Velasco.

GÜMBELINA VELASCOENSIS (Cushman)

Plate 4, fig. 14

Textularia velascoensis CUSHMAN, Contrib. Cushman Lab. Foram. Res., vol. 1, no. 1, 1925, p. 18, pl. 3, fig. 1; Bull. Amer. Assoc. Petr. Geol., vol. 10, no. 6, 1926, p 584, pl. 15, fig. 8.

Bolivinoides velascoensis (CUSHMAN), Journ. Pal., vol. 1, no. 2, 1927, p. 159, pl. 28, fig. 10.

Description.—Test oval in outline with bluntly rounded ends, sides convex; sutures limbate, raised with irregular projections extending back from the sutures themselves onto the surface of the chambers; aperture a semilunate opening at the base of the last chamber, parallel to the suture line.

Height of figured specimen, 0.75 mm.; greatest width, 0.55 mm.; greatest thickness, 0.3 mm.

Occurrence.—This species occurs as a rare form from the base of the Velasco through a considerable portion of the lower part of that formation, becoming common near the top of the lower Velasco and passing into the middle Velasco for a short distance.

This species lacks the two chief characteristics of a *Bolivinoides*, the thickening tissue obscuring the suture on the apertural face and the fissurine aperture.

The figured specimen is from locality No. 2.

Genus PSEUDOTEXTULARIA Rzehak, 1886

Pseudotextularia RZEHAK, Verh. naturf. Ver. Brünn, Sitz., vol. 24, 1885 (1886), p. 8 ("a form near *Textularia* will be designated by the name *Pseudotextularia* either as a monstrosity or a new genus"); Verh. k. k. geol. Reichsanst. Wien, 1888, p. 191 (monstrous forms of *Cuneolina* earlier designated as *Pseudotextularia*); Ann. k. k. naturhist. Hofmus. vol. 6, 1891, designated as *Cuneolina elegans* n. sp. forms which are textularian in the young and with clustered chambers in the adult, earlier called *Pseudotextularia*).

Genotype (monotypic) *P. varians* RZEHAK, Ann. k. k. naturhist. Hofmus., vol. 10, 1895, p. 217, pl. 7, figs. 2, 3, designated as type of the species, not fig. 1, which is *Gümbelina elegans* (RZEHAK). ("Altertiar", probably Upper Cretaceous, Bruderndorf, Austria.)—CUSHMAN, Journ. Washington Ac. Sci., vol. 15, no. 6, 1925, p. 133; Contrib. Cushman Lab. Foram. Res., vol. 2, pt. 1, 1926, p. 17.

Gümbelina (part) EGGER, Abh. Math.-Phys. Cl. der König. Bay. Akad. Wiss., München, vol. 21, 1902, p. 35, pl. 14, figs. 8, 9.

Description.—Test free, conical or pyramidal; early portion biserial like *Gümbelina*, the length of which varies with the megaspheric or the microspheric generation and with the species; later portion with globular chambers added to the periphery of the cone, making a multiserial test; wall calcareous, finely perforate, vertically striate, pustulose or smooth; aperture textularian in the biserial stage, one to each chamber in the adult, opening into a central vestibule.

PSEUDOTEXTULARIA VARIANS Rzehak

Plate 4, fig. 15

Pseudotextularia varians RZEHAK, Ann. k. k. naturhist. Hofmus., vol. 10, 1895, p. 217, pl. 7, figs. 2, 3, only.

Gümbelina fructicosa EGGER, Abh. Math.-Phys. Cl. der König. Bay. Akad. Wiss., München, vol. 21, 1902, p. 35, pl. 14, figs. 8, 9.

Description.—Test conical, round in cross-section; with or without longitudinal striations; apertures unobserved.

Height of figured specimen, 0.75 mm.; greatest diameter, 0.5 mm.

Occurrence.—This variety of the species is found as a rare form in the lower portion of the Mendez and as abundant in the middle and upper portions.

The figured specimen is from locality No. 29.

PSEUDOTEXTULARIA VARIANS var. MENDEZENSIS, n. var.

Plate 4, fig. 16

Pseudotextularia varians CUSHMAN, Contrib. Cushman Lab. Foram. Res., vol. 2, pt. 1, 1926, p. 17, pl. 2, fig. 4; Journ. Pal., vol. 1, no. 2, 1927, p. 157, pl. 27, fig. 2.

Description.—Test conical, flattened, elliptical in cross-section; with or without longitudinal striations; apertures unobserved.

Length of type specimen, 0.8 mm.; greatest width, 0.55 mm.; greatest thickness, 0.35 mm.

Holotype.—Columbia University Paleo. Coll. No. 19920, from locality No. 3.

Occurrence.—This variety of the species occurs as an abundant form throughout the Mendez, being somewhat greater in numbers in the middle portion.

PSEUDOTEXTULARIA VARIANS var. TEXTULARIFORMIS, n. var.

Plate 4, fig. 17

Gümbelina acervulinoides (part) EGGER, Abh. Math.-Phys. Cl. der König. Bay. Akad. Wiss., München, vol. 21, 1902, p. 36, pl. 14, figs. 14-16 only.

Description.—This is the variety which is first to be developed from *Gümbelina elegans,* the characteristics of which it retains in its early portion, the later portion becoming multiserial but still retaining its ancestral shape; apertures unobserved.

Length of type specimen, 0.7 mm.; width, 0.6 mm.; thickness, 0.3 mm.

Holotype.—Columbia University Paleo. Coll. No. 19921, from locality No. 3.

Occurrence.—This variety of the species is abundant throughout the Mendez, with a greater number, compared with the two other varieties, in the basal portion.

Genus EOUVIGERINA Cushman, 1926

Genoholotype *E. americana* CUSHMAN, Contrib. Cushman Lab. Foram. Res., vol. 2, pt. 1, 1926, p. 3, pl. 1, fig. 1.=*Sagrina cretacea* HERON-ALLEN and EARLAND.

Loxostomum (part) EHRENBERG, Mikrogeologie, 1854, pl. 27, figs. 21, 22.

Sagrina HERON-ALLEN and EARLAND, Journ. Roy. Mic. Soc., 1910, p. 423, pl. 8, figs. 8-10.

Description.—Test free, minute, elongate; nucleoconch in the microspheric form sometimes planispirally coiled; later chambers slight-

ly inflated and arranged biserially; wall calcareous, hyaline, very faintly perforate, smooth, granular, or spinose or angled on the lower part of each chamber; aperture circular, oval or rhomboidal, at the end of a neck, usually with phialine lip, situated near the axis of the test and usually inclined toward it.

EOUVIGERINA CRETACEA (Heron-Allen and Earland)

Plate 4, fig. 18

Sagrina cretacea HERON-ALLEN and EARLAND, Journ. Roy. Mic. Soc., 1910, p. 423, pl. 8, figs. 8-10.

Eouvigerina americana CUSHMAN, Contrib. Cushman Lab. Foram. Res., vol. 2, pt. 1, 1926, p. 4, pl. 1, fig. 1.

Description.—Test elongate, elliptical in outline, slightly broader toward the apertural end; early portion often planispiral, somewhat compressed and indistinct, later chambers distinct, with the upper face convex, the sides concave making an angled chamber with a sharp periphery on the upper edge; wall smooth or very finely granular; aperture at the end of a neck with a phialine lip.

Height of figured specimen, 0.6 mm.; greatest width, 0.2 mm.; greatest thickness, 0.15 mm.

Occurrence.—This species occurs as a rare form in the lower part of the upper portion of the Papagallos, becomes quite abundant in the uppermost Palagallos and through the lower portion of the Mendez, gradually becoming rarer until it is exceedingly rare in the very base of the Velasco.

The Mexican form appears to be just as closely related to the English as the Texas form, and all three to be very much alike, especially when one allows for the necessary latitude in figuring. Rather than make three species or varieties I prefer to include all under the one species.

The figured specimen is from locality No. 22.

Genus BOLIVINA d'Orbigny, 1839

Genotype (designated by CUSHMAN, U. S. Nat. Mus. Bull. 71, pt. 2, 1911, p. 31) *B. plicata* D'ORBIGNY, Voy. Amér. Mérid., vol. 5, pt. 5, 1839, Foraminifères, p. 61, pl. 8, figs. 4-7. (Recent, off Valparaiso, Chile.)

Description.—Test free, elongate, flattened; chambers biserial, two series showing on the flattened sides, closely appressed, edges of test usually angled, sometimes flanged or spinose; wall calcareous, thin,

hyaline, finely perforate; aperture at the base of the last chamber, elongate in the direction of flattening of the test; surface smooth or ornamented with striae, costae, knobs, spines, puncta, etc.

BOLIVINA DECORATA Jones

Plate 5, fig. 1

Bolivina decorata JONES, a manuscript species described and figured by WRIGHT, Proc. Belfast Nat. Field Club, 1884-1885, p. 330, pl. 27, figs. 7, 8.—HERON-ALLEN and EARLAND, Journ. Roy. Micr. Soc., 1910, p. 409, pl. 7, figs. 1, 2.—CUSHMAN, Bull. Amer. Assoc. Petr. Geol., vol. 10, no. 6, 1926, p. 586, pl. 15, fig. 11.

Bolivinoides decorata var. *delicatula* CUSHMAN, Contrib. Cushman Lab. Foram. Res., vol. 2, pt. 4, 1927, p. 90, pl. 12, fig. 8; Journ. Pal., vol. 1, no. 2, 1927, p. 158, pl. 28, fig. 7.

Description.—Test irregularly oval in outline being broader near the apertural end than at the apical; chambers oblique and low; sutures slightly limbate and depressed with longitudinal extensions over the intersutural spaces, giving the test a reticulate surface; aperture typical, at the base of the last chamber, elongate in the direction of flattening of the test.

Height of figured specimen, 0.7 mm.; greatest width, 0.3 mm.; greatest thickness, 0.17 mm.

Occurrence.—This species occurs as a rare form from the base of the Mendez to the limit of the Velasco as treated in this paper.

The form figured by Wright differs from that figured here in the general shape of the test. Specimens occur in Mexico, especially among the young of the species, which are closer to the type. In view of the changes among the Mexican specimens, I do not feel the difference to be of sufficient weight to warrant making a new variety.

Cushman has placed this form in the genus *Bolivinoides*, but as it lacks the thickening tissue obscuring the suture on the apertural face, and the nearly terminal fissurine aperture, which characterizes that genus, I have included it under *Bolivina*.

The figured specimen is from locality No. 30.

BOLIVINA INCRASSATA Reuss

Plate 4, fig. 19

Bolivina incrassata REUSS, Haidinger's Naturw., vol. 4, 1850 (1851), p. 45, pl. 4, fig. 13.—CUSHMAN, Contrib. Cushman Lab. Foram. Res., vol. 2, pt. 1, 1926, p. 19, pl. 2, fig. 1; vol. 2, pt. 4, 1927, p. 86, pl. 12, fig. 1; Journ. Pal., vol. 1, no. 2, 1927, p. 161, pl. 28, fig. 11.

Description.—Test oval in outline, stout, with rounded edges; sutures distinct, oblique, slightly depressed; wall smooth; aperture elongate, oval, with very slight lip.

Height of figured specimen, 1.1 mm.; greatest width, 0.5 mm.; greatest thickness, 0.3 mm.

Occurrence.—This species occurs as a very rare form in the uppermost beds of the Papagallos. It is often found as an abundant form in the Mendez, being found all through that formation but not extending into the Velasco.

The figured specimen is from locality No. 17.

BOLIVINA PRIMATUMIDA, n. sp.

Plate 4, fig. 20

Bolivina elongata EGGER (not HANTKEN), Abh. Math.-Phys. Cl. der König. Bay. Akad. Wiss., München, vol. 21, 1902, p. 44, pl. 16, figs. 12, 13.

Description.—This species is smaller, more slender, than the preceding, characterized by a swollen megaspheric proloculum; the sutures are more pronounced, appearing to be somewhat limbate, depressed, oblique, and relatively higher than in the preceding species; aperture elongate, comma-like, without lip.

Height of type specimen, 0.55 mm.; greatest width, 0.17 mm.; greatest thickness, 0.1 mm.

Holotype.—Columbia University Paleo. Coll. No. 19922, from locality No. 30.

Occurrence.—This species occurs as a rare to common form from the middle of the upper portion of the Papagallos through the Velasco as treated in this paper.

Genus BOLIVINOIDES Cushman, 1927

Genoholotype *Bolivina draco* MARSSON, Mitth. Nat. Ver. Neu-Vorpommern u. Rügen, vol. 10, 1878, p. 157, pl. 3, fig. 25. (Top of the Cretaceous, Rügen.)
Bolivinoides CUSHMAN, Contrib. Cushman Lab. Foram. Res., vol. 2, pt. 4, 1927, p. 89.

Description.—Test free, rhomboid, flattened, thickest toward the apertural end; chambers biserial, closely appressed, short and broad; wall calcareous, finely perforate; surface ornamented with costae or raised lobes which are at right angles to the sutures between the chambers, and largely obscuring chambers, the front end of the test with much thickening tissue without ornamentation; aperture fissurine, nearly terminal.

BOLIVINOIDES DRACO (Marsson)

Plate 5, fig. 2

Bolivina draco MARSSON, Mitth. Nat. Ver. Neu-Vorpommern u. Rügen, vol. 10, 1878, p. 157, pl. 3, fig. 25.

Bolivina rhomboidea CUSHMAN, Contrib. Cushman Lab. Foram. Res., vol. 2, pt. 1, 1926, p. 19, pl. 2, fig. 3.

Bolivinoides rhomboidea CUSHMAN, Contrib. Cushman Lab. Foram. Res., vol. 2, pt. 4, 1927, p. 90, pl. 12, fig. 10; Journ. Pal., vol. 1, no. 2, 1927, p. 158, pl. 28, fig. 12.

Description.—This species is characterized by the surface ornamentation which obscures the chambers. It consists of two nearly parallel median costae, from which oblique costae branch toward the periphery, these may or may not be connected by short transverse costae, all ending at the periphery in a raised, smooth surface; aperture fissurine, nearly terminal.

Height of figured specimen, 0.55 mm.; greatest width, 0.4 mm.; greatest thickness, 0.15 mm.

Occurrence.—This species occurs as a very rare form in the uppermost beds of the Papagallos, becomes quite common in the lower portion of the Mendez, gradually becoming rare again until it disappears in the base of the Velasco.

There seems to be no difference in the Mexican form without the transverse costae and Marsson's form.

The figured specimen is from locality No. 20.

Genus BIFARINA Parker and Jones, 1872

Genotype (monotypic) *Dimorphina saxipara* EHRENBERG, Mikrogeologie, 1854, pl. 32, II, fig. 27. (Upper Cretaceous, upper Mississippi Valley.)

Bifarina PARKER and JONES, Ann. Mag. Nat. Hist., ser. 4, vol. 10, 1872, p. 198.

Rectobolivina CUSHMAN, Contrib. Cushman Lab. Foram. Res., vol. 3, pt. 1, 1927, p. 68.

Description.—Test free, flattened in the early portion, which is biserial, flattened or round in the later portion, which is uniserial; wall calcareous, hyaline, very finely perforate; aperture terminal, round, simple, at the end of a slight projection or neck, with or without a slight raised lip.

BIFARINA NODOSARIA, n. sp.

Plate 5, fig. 3

Description.—This species has a very minute test with a flattened

textularian early portion and a nodosarian later portion; aperture simple, at the end of a protuberance.

Height of type specimen, 0.4 mm.; greatest width of textularian portion, 0.15 mm.; diameter of nodosarian portion, 0.1 mm.

Holotype.—Columbia University Paleo. Coll. No. 19923, from locality No. 14.

Occurrence.—This species, which is one of the finest guide fossils of the region, occurs in abundance at the very base of the Velasco.

This form is so small that it is best detected in the sample by transmitted light.

Family BULIMINIDAE Jones, 1876

Genus TURRILINA Andreae, 1884

Genotype (monotypic) *T. alsatica* ANDREAE, Abh. geol. Specialkarte Elsass-Loth., vol. 2, pt. 3, 1884, p. 212, pl. 8, fig. 18. (Middle Oligocene, Alsace.)
Not *Turrilina* CUSHMAN, Contrib. Cushman Lab. Foram. Res., vol. 3, pt. 1, 1927, p. 65.

Description.—Test free, coiled in a high, regular, turrited spire; chambers numerous, three to a coil; wall calcareous, finely perforate, smooth; aperture a simple, elongate slit at the base of the last chamber, oblique to the axis of the test.

TURRILINA TROCHOIDES (Reuss)

Plate 5, fig. 4

Globigerina trochoides REUSS, Verstein. Böhm. Kreide, 1845-46, p. 36, pl. 12, fig. 22; Haidinger's Naturw., vol. 4, 1850, (1851), p. 37, pl. 3, fig. 5.

Description.—Test trochoid; chambers rapidly enlarging, three to a whorl, the last chamber being as large as the two preceding chambers which are in turn as large as the remainder of the test.

Height of figured specimen, 0.3 mm.; greatest diameter, 0.3 mm.

Occurrence.—This species occurs as a rare form from the base of the middle portion of the Mendez to a point about in the middle of the lower portion of the Velasco.

The figured specimen is from locality No. 23.

Genus BULIMINA d'Orbigny, 1826

Genotype (designated by CUSHMAN, U. S. Nat. Mus. Bull. 71, pt. 2, 1911, p. 76.) *B. marginata* D'ORBIGNY, Ann. Sci. Nat., vol. 7, 1826, p. 269, pl. 12, figs. 10-12. (Recent, Adriatic, near Rimini.)

Description.—Test free, tapering, high-spired; chambers numerous, usually three to a volution; wall calcareous, hyaline, finely perforate; surface smooth or costate or spinose; aperture comma-shaped, broadest above, nearly vertical, extending from the last suture up into the last septal face, sometimes with vertical, plate-like tooth.

BULIMINA ACULEATA d'Orbigny

Plate 5, fig. 5

Bulimina aculeata D'ORBIGNY, Ann. Sci. Nat., vol. 7, 1826, p. 269, a reidentification of SOLDANI'S *Polymorpha pineiformia*, Testaceographica, vol. 1, pt. 2, 1791, p. 118, pl. 127 I, pl. 130 W; Fornasini, Mem. Accad. Sci. Isti. Bologna, ser. 5, vol. 9, 1901, p. 373, fig. 4, D'ORBIGNY'S figure.—PLUMMER, U. Texas Bull. 2644, 1927, p. 74, pl. 4, fig. 3.

Description.—Test minute, top-shaped; edges of chambers extending into spines which are generally broken off short, rest of chamber smooth; aperture typical.

Height of figured specimen, 0.28 mm.; greatest diameter, 0.2 mm.

Occurrence.—This species occurs as a rare form through the lower Velasco.

This species I have identified as *B. aculeata*, because the ornamentation consists of spines, resembling very closely the form figured by Plummer. Forms from the literature bearing this name, vary greatly, due to the size and shape of the test as well as the size and number of spines.

The figured specimen is from locality No. 8.

BULIMINA cf. INCISA Cushman

Plate 5, fig. 6

Bulimina incisa CUSHMAN, Bull. Amer. Assoc. Petr. Geol., vol. 10, no. 6, 1926, p. 592, pl. 17, fig. 9.

Description.—This species is characterized by re-entrants in the sutures and the broadly oval aperture; very faint striations cover the entire surface of the test.

Height of figured specimen, 0.55 mm.; greatest diameter, 0.35 mm.

Occurrence.—This species occurs as a rare form in the lower portion of the Velasco but becomes quite common before reaching the limit of that formation as treated in this paper.

Though this form has the very faint striations, which might miss detection in many cases, and in some specimens a rounded initial end

and in others a rather pointed initial end, it is the only form I find which has the characteristics enumerated by Cushman.

The figured specimen is from locality No. 30.

BULIMINA INFLATA Seguenza

Plate 5, fig. 7

Bulimina inflata SEGUENZA, Atti. Acc. Gioenia Sci. Nat. Catania, ser. 2, vol. 18, 1862, p. 109, pl. 1, fig. 10.—cf. CUSHMAN, Bull. Amer. Assoc. Petr. Geol., vol. 10, no. 6, 1926, p. 591, pl. 17, fig. 7.

Description.—The distinctive characteristic of this species is the longitudinal plications on the surface of the chambers, covering all but the upper portions of the last couple chambers.

Height of figured specimen, 0.5 mm.; greatest diameter, 0.3 mm.

Occurrence.—This species occurs as a rare to common form throughout the Velasco as treated in this paper.

The figured specimen is from locality No. 30.

BULIMINA INTERMEDIA Reuss

Plate 5, fig. 8

Bulimina intermedia REUSS, Verstein. Böhm. Kreide., 1845-46, p. 37, pl. 13, fig. 71; Haidinger's Naturw., vol. 4, 1850 (1851), p. 39, pl. 3, fig. 11.—ELEY, Geol. in the Garden, 1859, p. 199, pl. 5, fig. 30.

Description.—Test roughly top-shaped; chambers rapidly enlarging; sutures markedly depressed in the last few chambers; surface smooth; three chambers to a whorl; aperture broad.

Height of figured specimen, 0.45 mm.; greatest diameter, 0.38 mm.

Occurrence.—This species occurs as a little better than rare form from the middle of the upper portion of the Papagallos through the middle portion of the Mendez.

The figured specimen is from locality No. 24.

BULIMINA LIMBATA, n. sp.

Plate 5, fig. 9

Description.—Test bluntly pyramidal with a rounded apertural end, the first few chambers often almost hidden by the later ones, giving the blunt appearance to the test; sutures limbate, raised, and ending in spines in some of the early chambers; aperture very large.

Height of type specimen, 1.00 mm.; greatest depth, 0.6 mm.

Holotype.—Columbia University Paleo. Coll. No. 19924, from locality No. 29.

Occurrence.—This species occurs as a common species in the uppermost beds of the Papagallos and the lowermost Mendez. It occurs as a very rare form throughout the remainder of the Mendez.

BULIMINA MENDEZENSIS, n. sp.

Plate 5, fig. 10

Description.—Test broadly oval; wall smooth, last chambers relatively large; characterized by a relatively large, round aperture, with a number of slight folds radiating from it.

Height of type specimen, 0.55 mm.; greatest diameter, 0.35 mm.

Holotype.—Columbia University Paleo. Coll. No. 19925, from locality No. 20.

Occurrence.—This species occurs as a rare form throughout the Mendez.

BULIMINA OVATA d'Orbigny

Plate 5, fig. 11

Bulimina ovata D'ORBIGNY, Foram. Foss. Vienne, 1846, p. 185, pl. 11, figs. 13, 14.—CUSHMAN, Bull. Amer. Assoc. Petr. Geol., vol. 10, no. 6, 1926, p. 591, pl. 17, fig. 8.

Description.—Test oval with well rounded ends; surface smooth; sutures somewhat indistinct; aperture typical.

Height of figured specimen, 0.5 mm.; greatest diameter, 0.27 mm.

Occurrence.—This species occurs as a rare form from the uppermost beds of the Papagallos through the base of the Velasco.

If the last chamber of the specimen figured here were to be omitted it would resemble very closely that figured by d'Orbigny.

The figured specimen is from locality No. 27.

BULIMINA OVULA Reuss

Plate 5, fig. 12

Bulimina ovulum REUSS, Geogn. Skizze Böhm., vol. 2, 1844, pt. 1, p. 215; Verstein. Böhm. Kreide., 1845-46, p. 37, pl. 13, fig. 73; Haidinger's Naturw., vol. 4, 1850 (1851), p. 38, pl. 3, fig. 9.—EGGER, Abh. Math.-Phys. Cl. der König. Bay. Akad. Wiss., München, vol. 21, 1902, p. 50, pl. 15, fig. 46.

Description.—This species is very much like *B. intermedia* but it is much slimmer and more oval than top-shaped in outline; the aperture is narrow rather than broad.

Height of figured specimen, 0.5 mm.; greatest diameter, 0.3 mm.

Occurrence.—This species occurs as a rare form from the middle of the Papagallos through the base of the Mendez.

The figured specimen is from locality No. 24.

BULIMINA VELASCOENSIS (Cushman)

Plate 5, fig. 13

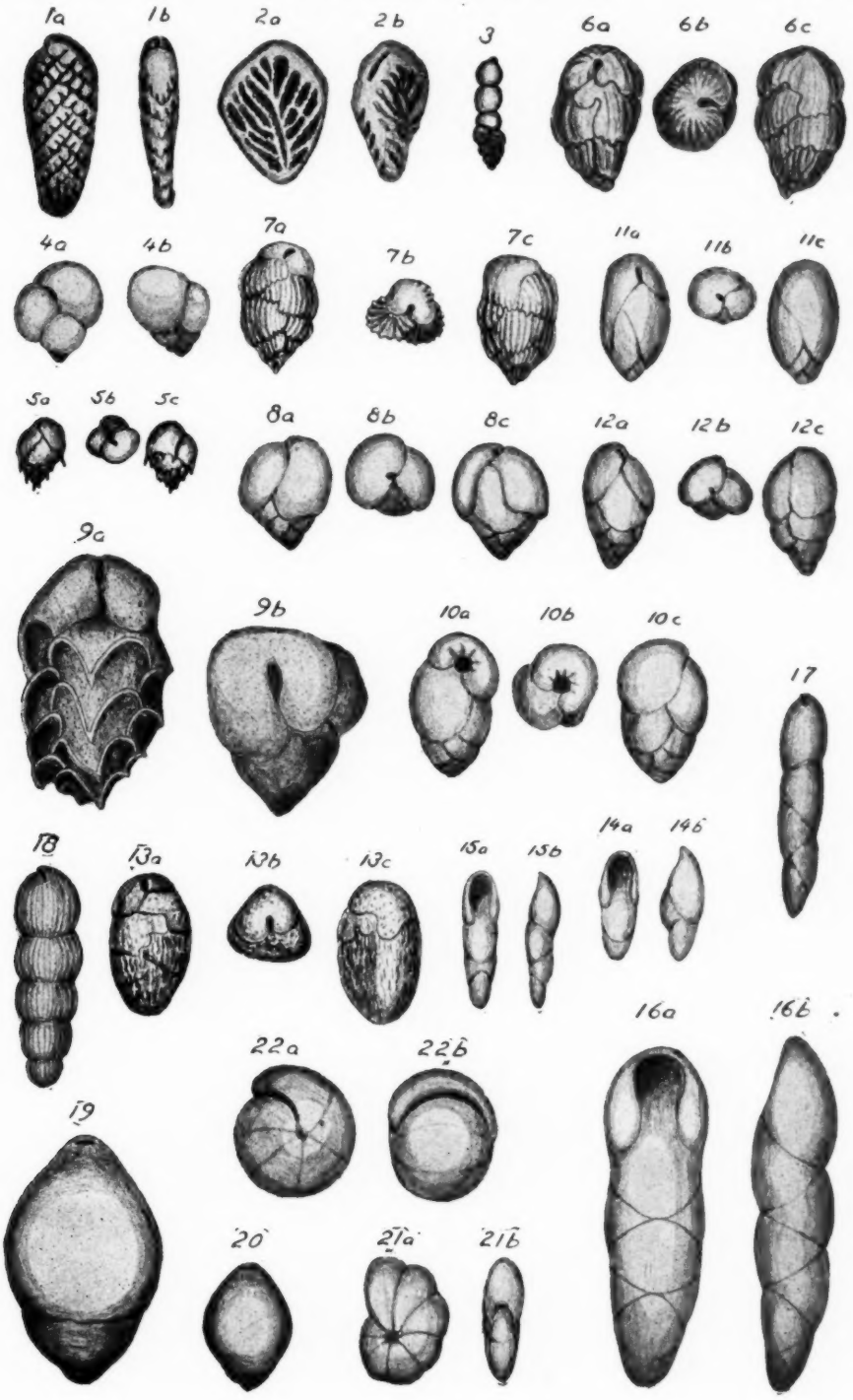
Gaudryina velascoensis CUSHMAN, Contrib. Cushman Lab. Foram. Res., vol. 1, no. 1, 1925, p. 20, pl. 3, fig. 7; Bull. Amer. Assoc. Petr. Geol., vol. 10, no. 6, 1926, p. 587, pl. 16, fig. 9; Journ. Pal., vol. 1, no. 2, 1927, p. 149, pl. 28, fig. 2.

Description.—Test broadly oval in outline, early portion triangular in cross-section, later portion may become somewhat quadrangular, angles broadly rounded; sutures indistinct except in the last few chambers; wall in the early portion of the test with numerous fine longitudinal striations, later portion smooth and coarsely punctate; aperture rather broad, oval.

Height of figured specimen, 0.53 mm.; greatest thickness, 0.3 mm.

EXPLANATION OF PLATE 5

FIG. 1.—*Bolivina decorata*, ×40.
2.—*Bolivinoides draco*, ×40.
3.—*Bifarina nodosaria*, ×40.
4.—*Turrilina trochoides*, ×40.
5.—*Bulimina aculeata*, ×40.
6.—*Bulimina incisa*, ×40.
7.—*Bulimina inflata*, ×40.
8.—*Bulimina intermedia*, ×40.
9.—*Bulimina limbata*, ×40.
10.—*Bulimina mendezensis*, ×40.
11.—*Bulimina ovata*, ×40.
12.—*Bulimina ovula*, ×40.
13.—*Bulimina velascoensis*, ×40.
14.—*Pleurostomella clavata*, ×40.
15.—*Pleurostomella subnodosa*, ×40.
16.—*Pleurostomella subnodosa* var. *gigantia*, ×40.
17.—*Ellipsoidella pleurostomelloides*, ×40.
18.—*Nodosarella striata*, ×40.
19, 20.—*Daucina chilostoma*, ×40.
21.—*Nonion scapha*, ×40.
22.—*Pullenia coryelli*, ×40.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21b

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Occurrence.—This species occurs as a common form in the upper portion of that part of the Velasco treated here.

Cushman's figures and descriptions lead me to believe his form must be the *Bulimina* figured here. The ornamentation would be rather unusual for an arenaceous form and if such a *Gaudryina* exists in the Velasco, it is strange that I should not have encountered it.

The figured specimen is from locality No. 30.

Family PLEUROSTOMELLIDAE Reuss, 1860

Genus PLEUROSTOMELLA Reuss, 1860

Genotype (designated by CUSHMAN, U. S. Nat. Mus. Bull. 71, pt. 2, 1911, p. 49) *P. subnodosa* REUSS, Sitz. k. Ak. Wiss., Wien, Math.-Naturw. Cl., vol. 40, 1860, p. 203, pl. 3, fig. 2. (Upper Cretaceous, Westphalia.)

Description.—Test free, elongate, subcylindrical or fusiform; chambers numerous, gradually or rapidly enlarging, triserial in the young and later biserial, biserial throughout, or biserial in the young and later staggered uniserial, and in the higher species tending to become glanduline and embrace the previous chambers; sutures conspicuous; wall calcareous, finely perforate, smooth; aperture an arched opening with a notch in the lower side, situated in a large depression at the top of the nearly erect septal face of the last chamber; a grooved, calcareous ribbon passes from the inside of the chamber at the top of the aperture down to the next earlier chamber above the aperture.

PLEUROSTOMELLA CLAVATA Cushman

Plate 5, fig. 14

Pleurostomella clavata CUSHMAN, Bull. Amer. Assoc. Petr. Geol., vol. 10, no. 6, 1926, p. 590, pl. 16, fig. 5; Contrib. Cushman Lab. Foram. Res., vol. 3, pt. 2, 1927, p. 132, pl. 25, fig. 19.

Description.—Test somewhat fusiform, nearly circular in cross-section, greatest diameter near apertural end; few chambers; sutures distinct but not depressed; wall smooth; aperture at base of last chamber, large, arched.

Height of figured specimen, 0.4 mm.; greatest diameter, 0.28 mm.

Occurrence.—This species occurs as a rare form throughout the Velasco as treated in this paper.

The figured specimen is from locality No. 23.

PLEUROSTOMELLA SUBNODOSA Reuss

Plate 5, fig. 15

Pleurostomella subnodosa REUSS, Sitz. k. Ak. Wiss. Wien, Math.-Naturw. Cl., vol. 40, 1860, p. 204, pl. 8, fig. 2.—HERON-ALLEN and EARLAND, Journ. Roy. Mic. Soc., 1910, p. 410, pl. 11, fig. 3.

Description.—Test elongate, subcylindrical, very gradually enlarging, early triserial or biserial, later biserial or staggered; aperture an arched opening.

Height of figured specimen, 0.5 mm.; greatest diameter, 0.15 mm.

Occurrence.—The occurrence of this species is practically the same as that of the preceding.

The figured specimen is from locality No. 23.

PLEUROSTOMELLA SUBNODOSA var. GIGANTIA, n. var.

Plate 5, fig. 16

Description.—Test elongate, subcylindrical, very large; alternating chambers throughout; aperture large, arched, simple.

Height of type specimen, 1.3 mm.; greatest diameter, 0.4 mm.

Holotype.—Columbia University Paleo. Coll. No. 19926, from locality No. 29.

Occurrence.—This species occurs as a very rare form from the uppermost Papagallos through the middle portion of the Mendez.

Genus ELLIPSOIDELLA Heron-Allen and Earland, 1910

Genotype (monotypic) *E. pleurostomelloides* HERON-ALLEN and EARLAND, Journ. Roy. Mic. Soc., Aug., 1910, p. 414, pl. 10, figs. 1-11. (Upper Cretaceous Selsey Bill, Sussex, England.)

? *Ellipsodimorphina* SILVESTRI, Boll. Acc. Gioenia Sci. Nat. Catania, n. ser., fasc. 69, p. 17. Description inadequate, no species or figures.

Ellipsosiphogenerina SILVESTRI, teste CUSHMAN, Bull. Amer. Assoc. Petr. Geol., vol. 10, no. 6, 1926, p. 591.

Description.—Test free, elongate, club-shaped; early chambers biserial, later chambers uniserial, either staggered or rectilinear; sutures conspicuous; wall calcareous, finely perforate, smooth; aperture terminal, crescentic, with overhanging lip; internally a grooved column extends from the apex of the preceding chamber to the apex of the succeeding one, where it is attached.

ELLIPSOIDELLA PLEUROSTOMELLOIDES Heron-Allen and Earland

Plate 5, fig. 17

Ellipsoidella pleurostomelloides HERON-ALLEN and EARLAND, Journ. Roy. Micr. Soc., 1910, p. 414, pl. 10, figs. 1-11, pl. 11, figs. 1, 2.

Pleurostomella subnodosa BURROWS, SHERBORN and BAILEY, Journ. Roy. Micr. Soc., 1890, p. 555, pl. 8, fig. 30 only.

Ellipsosiphogenerina sp? CUSHMAN, Bull. Amer. Assoc. Petr. Geol., vol. 10, no. 6, 1926, p. 591, pl. 20, figs. 11, 12.

Description.—Nothing need be added to the generic description for this species.

Height of figured specimen, 0.7 mm.; greatest diameter, 0.2 mm.

Occurrence.—This species occurs as a rare form from the uppermost Papagallos through the lower portion of the Velasco.

The figured specimen is from locality No. 23.

Genus NODOSARELLA Rzehak, 1895

Genotype *Lingulina rotundata* D'ORBIGNY, Foram. Foss. Vienne, 1846, p. 61, pl. 2, figs. 48-51. (Middle Miocene, Baden, Vienna Basin.)

Nodosarella RZEHAK, Ann. k. k. naturhist. Hofmus., vol. 10, 1895, p. 220.—SILVESTRI, Atti Soc. Ital. Sci. Nat., vol. 64, 1925, p. 52.

Ellipsonodosaria SILVESTRI, Atti Rend. R. Acc. Sci. Lett. Arti. Zelanti, Acireale, Mem. Cl. Sci., vol. 10, 1900, p. 4. Monotypic, typonym of *Nodosarella.*—SILVESTRI, Rev. Ital. Pal. anno 29, 1923, p. 15.—MARTINOTTI, Atti Soc. Ital. Sci. Nat., Mus. Civ. Stor. Nat. Milano, vol. 62, 1923, p. 345.

Pleurostomella SCHUBERT, Abh. k. k. geol. Reichs., vol. 20, pt. 4, 1911, p. 59; Neues Jahrb., 1911, vol. 2, p 320; Pal. Zeitschr., vol. 3, pt. 2, 1920, p. 186. Monotypic, *Pleurostomella barroisi* BERTHELIN.

Description.—Test free, elongate, round in cross-section; chambers several, uniserial, regularly arranged or staggered in the early portion of the test; wall calcareous, hyaline, very finely perforate; aperture terminal, crescentic; a calcareous, grooved column extends from the top of the preceding to the apex of the succeeding chamber.

NODOSARELLA STRIATA, n. sp.

Plate 5, fig. 18

Description.—Test elongate, rectilinear throughout; surface very finely striate.

Height of type specimen, 0.85 mm.; greatest diameter, 0.27 mm.

Holotype.—Columbia University Paleo. Coll. No. 19927, from locality No. 23.

Occurrence.—This species occurs as a rare form from the uppermost Papagallos through the Velasco as treated in this paper.

Genus DAUCINA Bornemann, 1855

Genotype (monotypic) *D. ermaniana* BORNEMANN, Erman's Archiv wiss. Kunde Russland, vol. 14, 1855, pp. 153-154, pl. 1, figs. 5-15. (Tertiary, near Rio de Janeiro at Corcovado.)

Ellipsoglandulina SILVESTRI, Atti Rend. R. Accad. Sci. Lett. Arti Zelanti, Acireale, Mem. Cl. Sci., vol. 10, 1900, p. 9.

Description.—Test free, oval; chambers several, arranged in a rectilinear manner or curved in the early portion of the test, rapidly enlarging, each embracing much of the previous one; wall calcareous, finely perforate, smooth; aperture terminal, crescentic, with or without notch in the concave side, with internal column.

DAUCINA CHILOSTOMA (Rzehak)

Plate 5, figs. 19, 20

Glandulina laevigata var. *chilostoma* RZEHAK, Ann. k. k. naturhist. Hofmus., vol. 10, 1895, p. 219, pl. 7, fig. 6.

Ellipsoglandulina velascoensis CUSHMAN, Bull. Amer. Assoc. Petr. Geol., vol. 10, no. 6, 1926, p. 590, pl. 16, fig. 7.

Description.—Test broadly oval; chambers rectilinear throughout or curved in the early portion; chambers few; wall smooth, aperture typical, without notch.

Height of larger specimen, 0.95 mm.; greatest diameter, 0.6 mm.

Occurrence.—This is a very rare form occurring in the middle portion of the Velasco.

The figured specimens are from locality No. 23.

Family NONIONIDAE Reuss, 1860

Genus NONION Montfort, 1808

Genoholotype *Nautilus incrassatus* FICHTEL and MOLL, Test. Micr., 1798, p. 38, pl. 4, figs. *a-c.* (Recent, Elba.)

Nonion MONTFORT, Conch. Syst., vol. 1, 1808, p. 210, fig.

Nonionina D'ORBIGNY, Ann. Sci. Nat., vol. 7, 1826, p. 293.

Description.—Test free, nautiloid, involute, biumbilicate, round on the back; chambers numerous, 8-12 in the last whorl, closely appressed; wall calcareous, hyaline, finely but distinctly perforate, smooth, sometimes with umbilical thickening; aperture a curved slit at the base of the septal face on the inner periphery.

NONION SCAPHA (Fichtel and Moll)

Plate 5, fig. 21

Nautilus scapha FICHTEL and MOLL, Test. Micr., 1798, p. 105, pl. 19, figs. *d-f*.
Nonion scapha CARSEY, U. Texas Bull. 2612, 1926, p. 49, pl. 1, fig. 2.

Description.—Test somewhat higher than broad, with about eight chambers in the last whorl; sutures curved, depressed; aperture characteristic.

Height of figured specimen, 0.45 mm.; width, 0.35 mm.; thickness, 0.15 mm.

Occurrence.—This species occurs as a rare form from the base of the middle portion of the Mendez to the limit of the Velasco as treated in this paper.

The figured specimen is from locality No. 30.

Genus PULLENIA Parker and Jones, 1862

Genoholotype *Nonionina bulloides* D'ORBIGNY, Ann. Sci. Nat., vol. 7, 1826, p. 293, not described; Foram. Foss. Vienne, 1846, p. 107, pl. 7, figs. 8-10. (Miocene, Vienna Basin.)

Pullenia PARKER and JONES, in CARPENTER, Introd. Foram., 1862, p. 184, pl. 12, fig. 12.—CUSHMAN, U. S. Nat. Mus. Bull. 71, pt. 4, 1914, p. 20. The type cannot be *P. sphaeroides* (D'ORBIGNY), as stated by CUSHMAN, since the type was originally designated and is different from *P. sphaeroides*.

Description.—Test free, spheroidal or compressed, planispiral and involute, leaving no previous whorls uncovered; chambers few in the last whorl, 3-7, closely appressed; sutures radial, nearly straight; wall calcareous, finely perforate, smooth; aperture a long, curved slit at the base of the last chamber on the inner periphery.

PULLENIA CORYELLI, n. sp.

Plate 5, fig. 22

Pullenia sphaeroides CUSHMAN (not D'ORBIGNY), Bull. Amer. Assoc. Petr. Geol., vol. 10, no. 6, 1926, p. 605, pl. 21, fig. 2.

Description.—Test subspherical, slightly higher than broad, with as many as six or seven chambers in the last whorl; sutures indistinct; surface smooth; aperture typical.

Height of type specimen, 0.5 mm.; width, 0.42 mm.

Holotype.—Columbia University Paleo. Coll. No. 19928, from locality No. 23.

Occurrence.—This species occurs as a common form from the base

of the middle portion of the Mendez throughout the Velasco as treated in this paper.

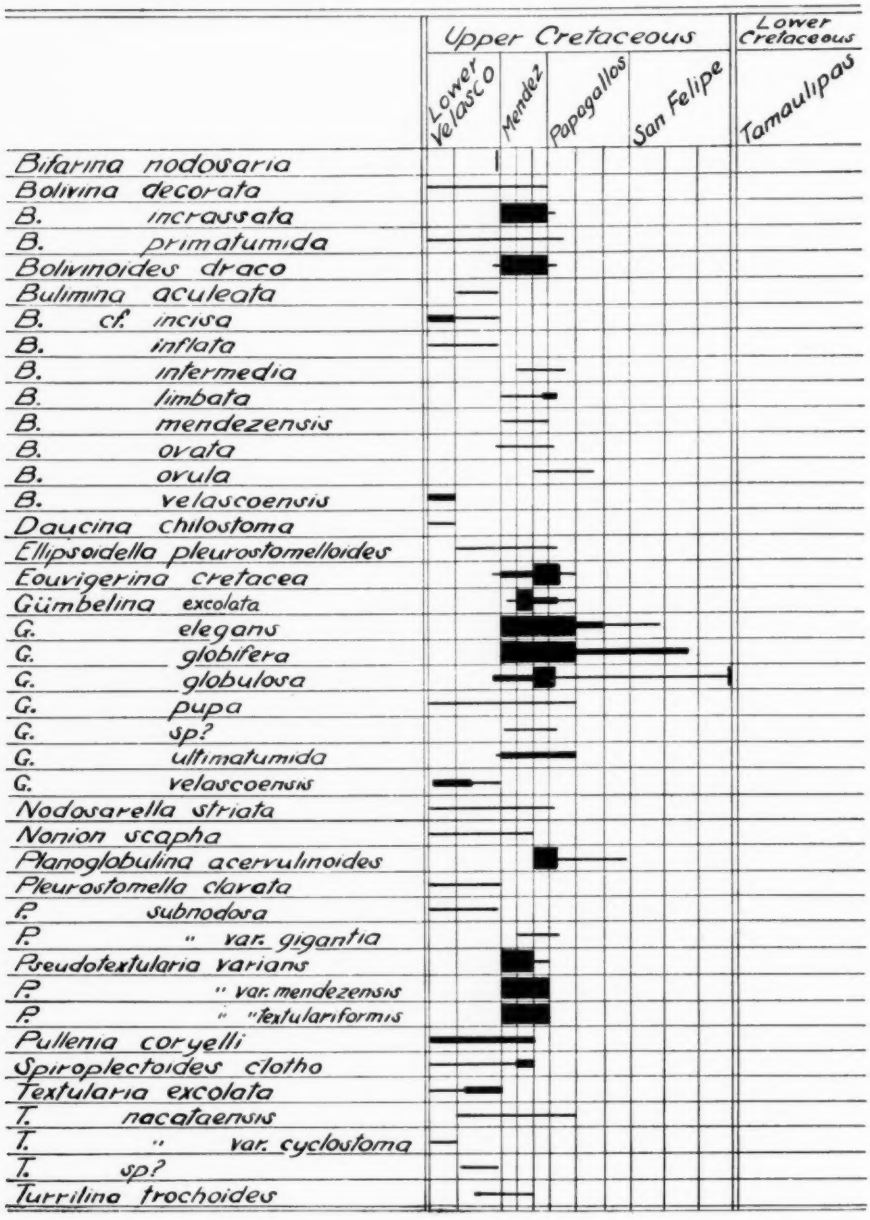
This species differs from the more recent forms in having a greater number of chambers and their indistinctness due to the lack of any depression of the sutures.

This species is named for Dr. H. N. Coryell.

Correction on Page 291—"Gyroidina aubangulata (Plummer)", should read "Gyroidina subangulata (Plummer)".

TABLE SHOWING THE RANGES

Width of Line Showing Relative Abundance



HEAVY MINERALS IN THE ROUBIDOUX AND OTHER SANDSTONES OF THE OZARK REGION, MISSOURI[1]

By CLETUS D. CORDRY

INTRODUCTION

ABSTRACT

The object of this investigation was to ascertain the value, for correlation purposes, of the heavy minerals contained in the various sandstones found in the Ozark Region of Missouri. Most of the sandstones are Cambro-Ordovician in age, but a few samples were taken from the Pennsylvanian sandstone, also found in this area. The conclusion is drawn that the formations cannot be differentiated by this method, and secondly that they were derived from a common source and probably from pre-existing sediments.

The discovery and development of new oil fields has created a demand for increased detail and exactness in the study of sedimentary formations. Every effort is being made to gather information concerning strata that may be of value in correlating them more definitely. Since drilling depths, and therefore costs, are gradually increasing, it becomes of prime importance to know the horizon at which one is drilling at all times. The exactness with which this can be done is determined by the precision with which the various formations can be correlated.

At the present time more detailed petrographic studies are being made of the sedimentary formations than ever before. These have been directed along two lines: (1) The study of micro-faunas; and (2) the investigation of detrital or heavy minerals. The micro-fossils are undoubtedly the more valuable, but often they either do not

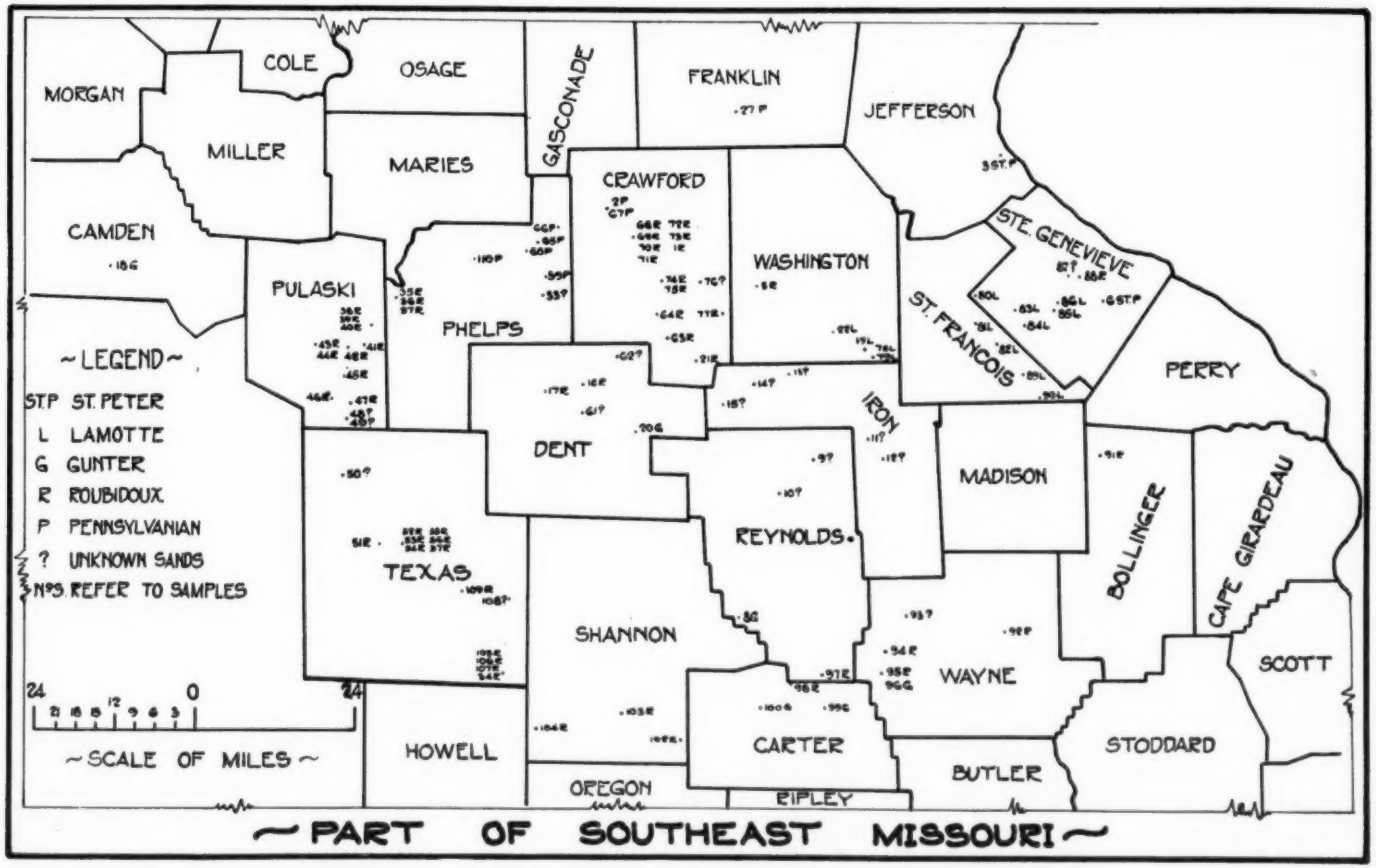
[1] A thesis submitted to the faculty of the School of Mines and Metallurgy of the University of Missouri in partial fulfillment of the work required for the degree of Master of Science, Rolla, Missouri, 1928.

exist or are so poorly preserved that they cannot be identified. It is in such formations that the detrital minerals may be of most value for correlation purposes. The fact that they are less likely to be destroyed by drilling, than micro-fossils, often renders them more available for study. For the above reasons it becomes important to consider the bearing that conditions of derivation may have upon the problem, and also to make exhaustive studies of their reliability in formations already correlated.

Since the heavy minerals are derived from the same source as the sedimentary beds themselves, they will be likely to vary from one locality to another. The presence of a suite of heavy minerals in one formation is no indication that the same suite may be contained in another formation of like geologic age in a different locality. Unlike the fossil content of a formation, which is rather uniform throughout widespread areas of the same geologic age, the heavy mineral content may or may not be constant, depending upon the character of the source from which it was derived. Whether the heavy minerals in one formation will be different from those in an overlying formation depends upon whether the sediments of the two formations were derived from a single source or from different sources. If from different sources, the two formations will probably contain different suites of heavy minerals, and thus afford a basis of discrimination. Since in any limited area a formation was probably derived from a single source, it is likely within that area to contain a single suite of heavy minerals. At more remote points material from other sources was probably introduced, and for this reason long range correlation, by means of heavy minerals is impracticable. The problem is related to paleogeographic conditions at the time the various sediments were being deposited. Therefore, their use for correlation purposes is a problem that will have to be worked out for each individual area under consideration.

In this study an attempt has been made to determine the usefulness of heavy minerals for correlations of formations over a limited area, in the heart of the Ozark uplift in southeast Missouri. The Roubidoux formation, already definitely correlated by other means, has been rather systematically sampled throughout the area, and the heavy minerals determined to ascertain their dependability for correlation purposes. Several samples from other horizons have been studied for comparison with the Roubidoux.

Also, within the area studied there are numerous isolated patches of sandstone, the horizons of which have not been definitely deter-


MORGAN
COLE
OSAGE
GASCONADE
FRANKLIN
JEFFERSON
MILLER
MARIES
CRAWFORD
CAMDEN
WASHINGTON
STE. GENEVIEVE
PULASKI
PHELPS
ST. FRANCOIS
PERRY
~LEGEND~
STP ST. PETER
L LAMOTTE
G GUNTER
R ROUBIDOUX
P PENNSYLVANIAN
? UNKNOWN SANDS
Nos. REFER TO SAMPLES
DENT
IRON
MADISON
BOLLINGER
CAPE GIRARDEAU
REYNOLDS
TEXAS
SHANNON
WAYNE
SCOTT
24 0 24
~SCALE OF MILES~
HOWELL
CARTER
STODDARD
OREGON
RIPLEY
BUTLER
~PART OF SOUTHEAST MISSOURI~

mined. Samples from a few such patches have been included in the study in order to determine whether it was possible to correlate them definitely by such means. No effort has been made to systematically sample and study these since the chief object was to obtain data upon known formations.

It is not to be assumed that the results of this limited study will definitely approve or condemn the method, but a body of data will have been assembled which may throw light not only on the correlation of these specific formations, but also on general problems of heavy mineral correlation.

Throughout the entire study the faculty members of the Geology Department have offered valuable suggestions from time to time. Dr. C. L. Dake collected most of the samples and critically read the manuscript. Dr. G. A. Muilenburg and Mr. L. W. Currier have given assistance and suggestions in the petrographic identifications. Dr. Schrenk of the Chemistry Department has very kindly offered his services from time to time. The Missouri Bureau of Geology and Mines very kindly furnished the necessary equipment for the investigation. Several advanced students in geology have aided in the preparation of samples for study, and also in the determination of the relative percentages of grains present.

Preparation of Samples for Petrographic Study

Only those methods used in this investigation will be discussed, as this subject has been adequately treated in numerous other places (see Bibliography).

Sampling

As already stated, the samples were taken from sandstone formations which are present in the Ozark region of southeast Missouri. This area includes roughly the southeast quarter of the state (plate 6), being bounded on the north by the Missouri River, on the east by the Mississippi River, on the south by the Arkansas-Missouri boundary line, and on the west by the 93rd meridian.

Most of the samples used were taken from outcrops, but in a few instances, where there could be little doubt as to its source, sandstone float was utilized.

In some instances suites of samples were taken at irregular intervals from bottom to top of the formation, but for the most part speci-

mens were chosen at random, and no effort was made to get composite or channel samples.

The five most important sandstone formations include the Lamotte, Gunter, St. Peter, Roubidoux, and Pennsylvanian, the Lamotte being the oldest. All of the sandstones do not outcrop over the entire area, but are more or less localized in certain portions.

In order to better grasp the relationships that exist among the various formations in this region a brief discussion of the stratigraphy and structural conditions follows. For geologic column see plate 7.

Stratigraphy of the Area

Pre-Cambrian

Pre-Cambrian rocks, composed chiefly of the granite and rhyolite porphyry, constitute what is known as the St. Francois Mountains. They are exposed in St. Francois, Washington, Iron, Ste. Genevieve, Wayne, Shannon, Carter, Crawford, and Madison counties. These Pre-Cambrian rocks represent the core of the Ozark uplift, and are simply the tops of the Pre-Cambrian mountains which have been exposed by the removal of overlying sedimentary beds.

The sediments rest unconformably upon these older crystallines and dip away from them in all directions, so that in going out from the center of the uplift one encounters successively younger and younger formations. The dip on the east side of the uplift being much greater than that on the west, the width of the outcropping formation is less there than on the west. The outcrops of sedimentary strata form more or less regular bands surrounding the crystalline core.

Cambrian System

Lamotte sandstone.—The following description represents an abstract of Buckley's[2] report and Dake's[3] unpublished manuscript.

The Lamotte formation is the basal sandstone of the Cambrian in this region. Since it rests unconformably upon the Pre-Cambrian crystalline rocks its distribution is confined to approximately the same area as the St. Francois Mountains, where it is found outcrop-

[2] Buckley, E. R., Geology of the disseminated lead district of St. Francois and Washington counties; Missouri Bureau of Geology and Mines, vol. IX, part. 1.

[3] Dake, C. L., Report on the Potosi-Edgehill Quadrangle; Missouri Bureau of Geology and Mines, in preparation.

ping around the borders of the porphyry knobs. It is composed largely of quartz sandstone, varying in color from light gray to reddish brown, red, and shades of yellow brown, depending upon the amount of iron.

Since it is a basal sandstone resting on a very uneven surface its thickness varies considerably. In fact it may vary from a few feet to possibly more than 250 feet in the Pre-Cambrian valleys.

Samples taken from outcrops of this formation come from a small area immediately surrounding the St. Francois Mountains in Washington, St. Francois, and Ste. Genevieve counties. The area sampled was more or less circular with a radius of 12 to 15 miles. As stated before, this sandstone is basal, resting on igneous rocks, and to avoid local irregularities in mineral content, the samples, so far as possible, were taken from the upper part of the formation.

The transition zone lying between the Lamotte and the Bonneterre dolomite is represented by dolomite and sandstone, extending in places through forty or fifty feet.

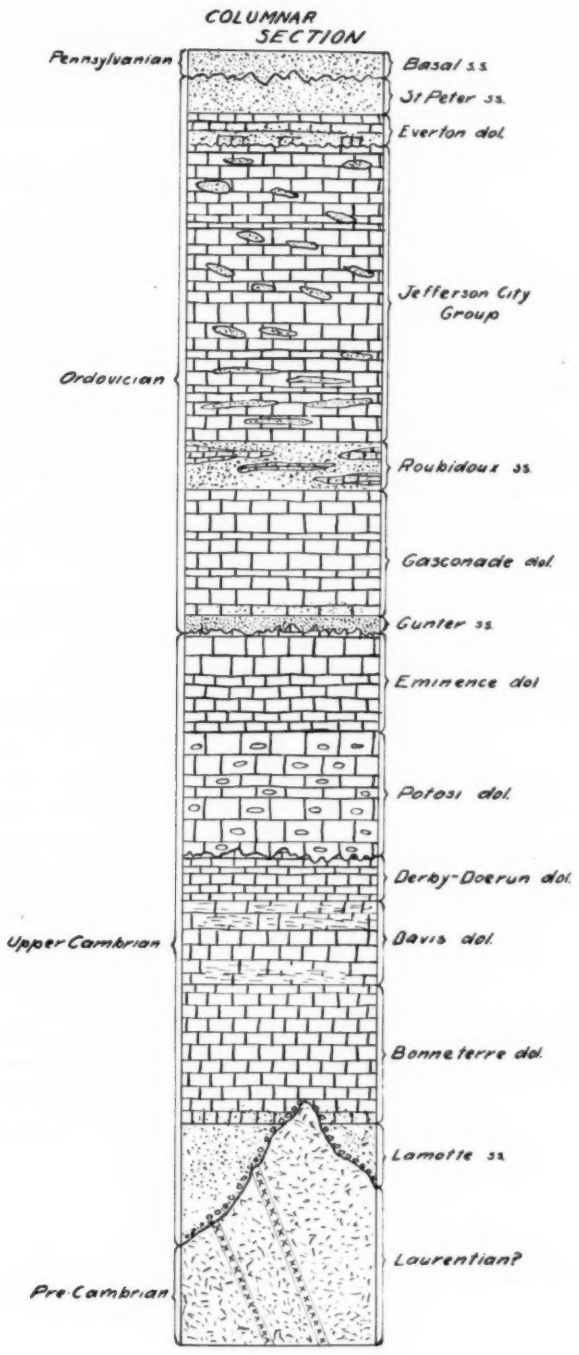
Bonneterre dolomite.—The Bonneterre formation is a massive, gray to buff, noncherty dolomite, with an average thickness of about 265 feet, but varying greatly since it overlaps the Lamotte sandstone onto the porphyry knobs.

Davis formation.—The Bonneterre dolomite grades conformably into the Davis formation, which is composed of thin bedded dolomitic limestone, and shales, with limestone predominating. Its average thickness is about 170 feet.

Derby-Doerun formations.—The Davis formation grades conformably into the Derby, a massive dolomite formation about 40 feet thick. Above this is the Doerun, an argillaceous dolomite about 50 feet in thickness. Outcrops are confined to areas within the vicinity of the St. Francois Mountains.

Potosi dolomite.—This formation outcrops widely in Washington, Iron, Crawford, Reynolds, Shannon, and Madison counties, where it is found resting unconformably on the Derby-Doerun, Davis, and Bonneterre. It consists of dark brown, massive dolomite with abundant quartz druses. The dolomite usually possesses a foetid odor on freshly broken surfaces. Its thickness is extremely variable, but may average 250 feet.

Eminence dolomite.—This formation is best known in Shannon county, where it has a thickness of more than 200 feet. It consists of light gray, massively bedded, cherty dolomite.


COLUMNAR SECTION
Pennsylvanian
Basal ss.
St Peter ss.
Everton dol.
Jefferson City Group
Ordovician
Roubidoux ss.
Gasconade dol.
Gunter ss.
Eminence dol
Potosi dol.
Derby-Doerun dol.
Upper Cambrian
Davis dol.
Bonneterre dol.
Lamotte ss.
Laurentian?
Pre-Cambrian

Ordovician System

Gasconade formation.—Gunter sandstone.—The Gunter sandstone is the basal member of the Gasconade. It consists of a very pure, light gray to brown, well cemented, often quartzitic sandstone. Its thickness ranges from a few feet up to 35 or more feet. Its type locality is Hahatonka Spring, Camden Co., and it is known in Morgan and Miller counties, but it also has a wide distribution in Shannon, Reynolds, Carter, Wayne, and Ste. Genevieve counties. It is sparingly developed in the central St. Francois Mountain area, but its horizon laps across all the older formations, due to the pre-Gunter erosion interval. A few samples were taken from outcrops in each area.

Above the Gunter member there is 250 feet or more of very cherty dolomite. This thick dolomitic member is much more widely known than the basal sand. Due to its thickness its upper beds are often found outcropping in deep valleys, where the Gunter is not exposed.

Roubidoux sandstone.—This is the most conspicuous and widespread sandstone in the Ozark region. In reality it is made up of sandstone and dolomite limestone lenses. The lenses are not widely persistent, but rapidly change from one locality to another, so that it is impossible to trace them throughout the entire area. The sandstone is medium to coarse grained, and generally ferruginous. Its thickness varies from 75 to 150 feet.

It outcrops entirely around the St. Francois Mountains, but is found in wider areas on the south, west, and northwest sides, because of the gentler dips in these directions. It caps a great many of the uplands in Dent, Crawford, Phelps, Pulaski, Texas, Reynolds, Shannon, Carter, Ripley, and Butler counties. It is also widely known in Camden, Morgan, and Miller counties. No samples were obtained from these last three counties, and only a very few from the east flank of the St. Francois Mountains, thus leaving the great majority from Phelps, Crawford, Pulaski, Texas, Shannon, and Dent counties. The entire area from which samples were taken is more or less circular with a radius of 30 to 40 miles.

Whenever it was possible the horizon within the formation was noted, and at a few places (plate 6), where good sections of the formation were exposed, samples were taken at irregular intervals from the base to the top.

Jefferson City group.—This group includes what are now known as the Jefferson City, Cotter, and Powell formations. They are es-

sentially argillaceous dolomites averaging probably more than 600 feet in thickness, with occasional sandstone lenses.

Everton formation.—The Everton consists of two members, the lower one being a sandy phase with interbedded limestone, and the upper a sandy limestone, with a total thickness of approximately 60 feet.

St. Peter sandstone.—This description was abstracted from Dake's[4] bulletin. The sandstone outcrops in this area as a narrow border, on the north and east slopes of the uplift. In south Missouri it rests upon the Everton, but to the north the Everton apparently becomes more and more sandy and finally grades into the St. Peter. Where the Everton is present in Ste. Genevieve and southern Jefferson counties, the St. Peter probably averages 60 feet in thickness, but farther to the north the two combined reach 115 feet or more. The St. Peter sandstone is noted for its high percentage of silica. Numerous analyses show a silica content varying from 96 to 99½ per cent. Only a few samples were selected from this horizon.

Above the St. Peter several other formations are present on the borders of the uplift, but in the central Ozark region the Pennsylvanian sandstone is the next overlying formation, except for one small patch of Devonian, and numerous areas of residual Mississippian chert.

Carboniferous System

Pennsylvanian sandstone.—This sandstone is found as remnants over a large part of the Ozark region, but it is most conspicuous in Phelps, Crawford, Maries, and Gasconade counties, where it is associated with clay deposits. Since there is a great unconformity at its base, it is found in contact with all formations down to the Potosi, and it often-times fills sinks which existed in the older formations. A few samples were collected in Phelps and Crawford counties.

A list showing the locations from which samples were taken is given below.

1.—Roubidoux—one mile north of Meramec River on Highway No. 19, Crawford County.
2.—Pennsylvanian—one mile south of Cuba, on Highway No. 19, Crawford County.
3.—St. Peter—Crystal City, Jefferson County.
4.—St. Peter—ten miles northwest of Winfield, Lincoln County. (Not shown on map.)

[4] Dake, C. L., Problem of the St. Peter sandstone; Missouri School of Mines and Metallurgy, Bull., vol. VI, no. 1, Aug., 1921.

5.—Roubidoux—NW. ¼ sec. 19, T. 37 N., R. 1 E., Washington County.
6.—St. Peter—River aux Vases, Ste. Genevieve County.
8.—Gunter—SE. ¼ sec. 7, T. 29 N., R. 1 W., Reynolds County.
9.—Sandstone float—where road crosses hill in NE. ¼ SE. ¼ sec 18, T. 33 N., R. 2 E. Occurs over 100 feet above the base of the Gasconade float. Probably a remnant of the Roubidoux.
10.—Sandstone float—on hillside along Highway No. 21, between Lesterville and Centerville, where road crosses the saddle in N. ½ sec. 15, T. 32 N., R. 1 E., Reynolds County. May be Gunter, Roubidoux, or Pennsylvanian.
11.—Sandstone float—top of hill along Highway No. 21, between Glover and Lesterville, near the center of sec. 5, T. 33 N., R. 3 E. Occurs about 100 feet above the lower margin of Gasconade float. Probably Roubidoux.
12.—Sandstone float—near the crest of Tip Top Mountain, along Highway No. 21, between Hogan and Arcadia. Abundant blocks far above lower margin of Gasconade float.
13.—Sandstone float—saddle along Highway No. 32, just west of Shepherd, Iron County, in NW. ¼ SW. ¼ sec. 36, T. 35 N., R. 1 E. Is resting on Potosi float. Possibly Gunter, more probably Roubidoux.
14.—Sandstone float—along Highway No. 32, in Iron County, in SW. ¼ SW. ¼ sec. 31, T. 35 N., R. 1 E. Heavy float above a considerable thickness of Gasconade float. Probably Roubidoux.
15.—Sandstone float—Highway No. 32 in west edge of Bixby, Iron County. About 100 feet above Eminence-Gasconade contact. Probably Roubidoux.
16.—Roubidoux—3½ miles east of Salem, Dent County, on temporary Highway No. 32, just east of a double right angled offset.
17.—Roubidoux—seven miles northwest of Salem, Dent County, at the Deep Ford school on Rolla-Salem road.
18.—Gunter—Hahatonka Spring, Camden County. Type locality.
19.—Lamotte—N. ½ sec. 7, T. 35 N., R. 3 E., Washington County.
20.—Gunter—two miles west of Stone Hill, on Highway No. 32 (temporary), elevation 1,130 feet, Dent County.
21.—Roubidoux—SW. ¼ sec. 12, T. 29 N., R. 2 W.
22.—Lamotte—center W. ½ sec. 36, T. 36 N., R. 2 E., Washington County.
27.—Pennsylvanian—coal mine at Anaconda, Franklin County.
33.—Sandstone float—one mile west of Meramec Spring on St. James road. Taken from top of hill and is probably Roubidoux.
34.—Roubidoux—Highway No. 17, on the north bank of Jack's Fork Creek at the Jack Fork Bridge, Texas County.
35.—Roubidoux—Highway No. 66, 1½ miles southwest of the Arlington bridge on the big hill. Basal two feet of the formation.
36.—Roubidoux—same as No. 35, except 35 feet above the base of the formation.
37.—Roubidoux—same as No. 35, except 60 feet above the base of the formation.
38.—Roubidoux—Highway No. 66, on the hill one mile northeast of Hooker. Basal conglomerate.
39.—Roubidoux—same as No. 38, except 2 feet above the base.
40.—Roubidoux—same as No. 38, except about 45 feet above the base.
41.—Roubidoux—Highway No. 66, west of the Devil's Elbow, about 20 feet above the big stone railing. Close to the base of the formation.

42.—Roubidoux—at the junction of Highway No. 66 and temporary Highway No. 28. One mile west of Devil's Elbow. Estimated to be 50 or 60 feet above the base of the formation.

43.—Roubidoux—top of the hill on Highway No. 66, one mile east of Waynesville. About 50 or 55 feet above the base of the formation.

44.—Roubidoux—same as No. 43, except within 10 feet of the base of the formation.

45.—Roubidoux—Highway No. 17, about 3 miles south of its junction with Highway No. 66. Taken from shallow road ditch on the ridge top, between 50 and 75 feet above the base of the formation.

46.—Roubidoux—road ditch along the ridge top one-half mile south of Bloodland on Highway No. 17.

47.—Roubidoux—at the school house where Highway No. 17 (temporary) crosses the first creek south of Bloodland. Conglomerate taken to be the base of the formation.

48.—Sandstone—just above sample No. 47. Roubidoux or Jefferson City.

49.—Sandstone—one miles south of samples No. 47 and 48, on the top of the ridge. Probably very high in the Roubidoux or it may be the Jefferson City.

50.—Sandstone—top of the ridge along Highway No. 17, one-half mile east of Roby. Either Roubidoux or Jefferson City.

51.—Roubidoux—top of the hill on Highway No. 17, three-fourths of a mile southeast of Bucyrus, on road to Houston. Near the top of the formation.

52.—Roubidoux—where Highway No. 17 crosses the Piney River, west of Houston. Twenty feet above the level of the river, and near the base of the formation.

53.—Roubidoux—same as No. 52, except 45 feet above the base.

54.—Roubidoux—same as No. 52, except 65 feet above the base.

55.—Roubidoux—same as No. 52, except 85 feet above the base.

56.—Roubidoux—same as No. 52, except 105 feet above the base.

57.—Roubidoux—same as No. 52, except 130 feet above the base.

59.—Pennsylvanian—NE. ¼ NW. ¼ sec. 35, T. 38 N., R. 6 W., about two miles northwest of Meramec Spring. Massive sandstone thought to be Pennsylvanian resting on thin bedded basal Roubidoux.

60.—Pennsylvanian—N. ½ NE. ¼ NE. ¼ sec. 29, T. 38 N., R. 6 E., along the road about one mile east of St. James.

61.—Sandstone—temporary Highway No. 19, about 2 miles northeast of Howe Station, Dent County. Probably Roubidoux very low in the formation.

62.—Sandstone—temporary Highway No. 19, in Dent County, about midway between Meramec River and Crooked Creek. Probably extreme base of the Roubidoux.

63.—Roubidoux—Highway No. 19, where it crosses the Palmer fault, about two miles southwest of Cherryville, Crawford County. About 40 to 50 feet above the base of the formation.

64.—Roubidoux—Highway No. 19, about midway between Cherryville and Steeleville, on top of the hill at Ernest A. Smith Memorial Chapel. Probably about middle Roubidoux.

65.—Pennsylvanian—road cut on Highway No. 66 (temporary), at the right angle turn 1—1¼ miles northeast of St. James.

66.—Pennsylvanian—from Highway No. 66 (temporary), one-fourth mile east of Phelps County-Crawford County line.

67.—Pennsylvanian—road cut on Highway No. 19, one mile south of Cuba.

68.—Roubidoux—Highway No. 19, between Cuba and Steeleville, on the hill north of the Meramec River bridge, about 10 to 15 feet from the top of the hill.

69.—Roubidoux—same as No. 68, except 20 feet below it.

70.—Roubidoux—same as No. 68, except 40 feet below it.

71.—Roubidoux—same as No. 68, except 60 feet below it.

72.—Roubidoux—same as No. 68, except 80 feet below it.

73.—Roubidoux—same as No. 68, except 110 feet below it, and within 10 or 15 feet of the base of the formation.

74.—Roubidoux—Highway No. 8, about one mile east of Steeleville, near the center of section 35, T. 38 N., R. 4 W. Base of the formation.

75.—Roubidoux—same as No. 74, except about 50 feet above the base.

76.—Sandstone—hill west of Huzzah Creek, on Highway No. 8 (temporary), NW. ¼ NE. ¼ sec. 35, T. 38 N., R. 3 W. Either basal Roubidoux or Pennsylvanian in sink structure.

77.—Roubidoux—Highway No. 8 (temporary), one mile west of Berryman, and just west of the Berryman fault in the SW. ¼ sec. 14, T. 37 N., R. 2 W.

78.—Lamotte—W. ½ SW. ¼ NW. ¼ sec. 8, T. 35 N., R. 3 E., on Caledonia-Bismark road. Horizon within the formation unknown.

79.—Lamotte—W. ½ SW. ¼ sec. 11, T. 35 N., R. 3 E., on the Caledonia-Bismark road. Horizon within the formation unknown.

80.—Sandstone—transition zone between the Lamotte and Bonneterre, where the 25 minute meridian (Ste. Genevieve Co. map) crosses Salem Creek, on the old Farmington-St. Louis road, in what would be, if the area were sectionized, the E. ½, sec. 25, T. 37 N., R. 5 E.

81.—Sandstone—transition zone between the Lamotte and the Bonneterre. About one mile south of Farmington Junction (Ste. Genevieve Co. map).

82.—Lamotte—where the Farmington-Ste. Genevieve road crosses Camp Creek near the center of sec. 33, T. 36 N., R. 6 E. Forty feet below the Bonneterre contact.

83.—Lamotte—Highway No. 32 (temporary), one mile southwest of Jonca, in SE. ¼ sec. 13, T. 36 N., R. 6 E. About 125 feet above the granite contact.

84.—Lamotte—where the Ste. Genevieve-Farmington road crosses the south fork of Jonca Creek in SW. ¼ NW. ¼ sec. 18, T. 36 N., R. 7 E. About 100 feet below sample No. 83.

85.—Lamotte—where the Ste. Genevieve-Farmington road crosses the railroad in NW. ¼ NW. ¼ sec. 4, T. 36 N., R. 7 E., about 140 feet above the granite contact.

86.—Lamotte—W. ½ NW. ¼ sec. 35, T. 37 N., R. 7 E. Very close to the top of the formation.

87.—Sandstone—within the fault zone in the railroad cut about one mile west of Weingarten in SW. ¼ sec. 26, T. 37 N., R. 7 E. Probably Roubidoux, or possibly Gunter.

88.—Roubidoux—in the railroad cut in Weingarten in NW. ¼ sec. 25, T. 37 N., R. 7 E. Within 20 feet of the base of the formation.

89.—Lamotte—Highway No. 61 in W. ½, sec. 14, T. 35 N., R. 6 E. Within 30 feet of the top of the formation.

90.—Lamotte—Highway No. 61 (temporary), in what would be, if the area were sectionized, the NW. corner sec. 20, T. 35 N., R. 7 E. About 50 feet below the top of the formation

91.—Roubidoux—Highway No. 61 (temporary), at center of SW. ¼ sec. 29, T. 33 N., R. 9 E. Horizon within the formation not known.

92.—Roubidoux—top of hill on Highway No. 54, about 3 miles east of its junction with Highway No. 67, Wayne County. Near the base of the formation.

93.—Sandstone float—Highway No. 34, at top of hill about 3 miles east of Piedmont, Wayne County. Either Gunter or Roubidoux in sink structure.

94.—Roubidoux—temporary Highway No. 34 at the highest point of the divide, about half way between Piedmont and Leeper, Wayne County. Low in the formation.

95.—Roubidoux—top of high hill along county road about 1½—2 miles east of Mill Springs, Wayne County. Base of the formation.

96.—Gunter—same as 95, except about 160 feet lower on the hill.

97.—Roubidoux—hill top at Garwood, Reynolds County, along Highway No. 34. Very base of the formation.

98.—Roubidoux—junction of Highways No. 21 and 60, Carter County. Basal beds.

99.—Gunter—about 5 miles east of Van Buren, on Highway No. 60, near the base of the big hill.

100.—Gunter—about two miles west of Van Buren, Carter County, on Highway No. 60 (temporary). About 10 feet above the saddle.

102.—Roubidoux—Highway No. 60, about 5 miles west of Fremont at the top of the ridge. Probably basal bed.

103.—Roubidoux—one mile west of Winona, Shannon County, on Highway No. 60. Horizon within the formation not known.

104.—Roubidoux—about one mile east of Teresita, in shallow valley on Highway No. 60. Horizon within the formation not known.

105.—Roubidoux—Highway No. 17, just north of Jack's Fork bridge. Extreme base.

106.—Roubidoux—same as No. 105, except 60 feet above the base.

107.—Roubidoux—same as No. 105, except 100 feet above the base.

108.—Sandstone—two miles NW. of Summersville on Highway No. 17 (temporary). Either top of Roubidoux or base of Jefferson City.

109.—Roubidoux—Highway No. 17 (temporary) between Eunice and Raymondsville, in NE. ¼ NE. ¼ sec. 33, T. 30, N., R. 8 W. Within 30 feet of the top of the formation.

110.—Pennsylvanian—Highway No. 63, 2 miles north of Rolla, Phelps County.

SEPARATION

The samples were crushed in an iron mortar with an iron pestle, care being taken to prevent any undue breaking of the individual grains. After a little practice this was accomplished with excellent results. In most cases the samples were sufficiently friable so that

no trouble in crushing was encountered, but a few highly quartzitic ones presented a problem that was not easily overcome. In such cases it is practically impossible to prevent breakage of grains. Whenever it was possible quartzitic bands in the sample were discarded, and the more loosely cemented material used.

After some preliminary experimenting with a few of the samples it was found that the total quantity of detrital minerals was small, therefore some means of preliminary concentration was necessary before attempting the final separation by means of acetylene tetrabromide. Panning 300 to 500 cc. of the crushed material was tried, but found inconvenient and time-consuming. Several samples, however, were concentrated by this method. Continued agitation and washing was carried on until the original material had been reduced in volume to 10 or 15 cc. Good crops of "heavies" were secured from the samples so treated but as stated above this method required painstaking care and more time than was available. Screening[5] was then resorted to and found to be much more satisfactory.

The concentration by screening is based upon the assumption that the heavy minerals in a sandstone are smaller in size than the average quartz grains themselves. When the difference in specific gravity of quartz and that of the detrital grains is considered along with the mechanics of sedimentation, it appears that the assumption is based on principles which are fundamentally true. A quartz grain of given size will be moved by the force of flowing water, whereas a mineral with greater specific gravity and equal size would be left undisturbed. Thus when the final resting place was reached the quartz grains would have associated with them smaller grains of the heavier detritals.

After studying screen tests made by Dake[6] on various sandstones, and after making some preliminary tests, a 60 mesh Tyler screen was selected as being suitable for most samples. This screen in the great majority of cases allowed from 10 to 30 per cent of the sand to pass. All material which passed the screen was further separated with acetylene tetrabromide.

In order to get some idea of whether concentration by screening resulted in any appreciable loss of the heavy mineral content, measurements were made of grains from those samples which had been panned, rather than screened. A comparison of these sizes with the size of the openings in a 60 mesh screen, suggests that only a very

[5] Suggested by Mrs. Fanny C. Edson of the Shell Petroleum Corp., Tulsa, Oklahoma.

[6] Dake, C. L., Problem of St. Peter sandstone; Missouri School of Mines and Metallurgy, Bull. Technical Series, vol. VI, no. 1, August, 1921.

few of the largest grains could have been lost by this process, Only a few of the largest grains in each slide were measured, and the results are presented in the accompanying table.

SIZE OF LARGEST GRAINS IN PANNED SAMPLES (mm.)

Sample No. 16	Sample No. 17	Sample No. 18	Sample No. 23
0.14 x 0.11	0.25 x 0.16	0.27 x 0.11	0.20 x 0.14
0.10 x 0.08	0.27 x 0.20	0.30 x 0.30	0.22 x 0.18
0.19 x 0.12	0.31 x 0.24	0.26 x 0.21	0.15 x 0.20
	0.26 x 0.16	0.24 x 0.08	0.22 x 0.14
	0.18 x 0.08	0.27 x 0.11	
	0.31 x 0.09		

Size of openings in screen 0.22 mm. to 0.24 mm.

The measurements show the long and short dimensions of the grains. In sample No. 16 all grains would have passed the screen. In sample No. 17 one grain would possibly have been retained on the screen, and undoubtedly one would have been retained in sample No. 18, while all grains in sample No. 23 would have passed. From the comparison it is seen that only two grains would have possibly been retained on the screen. A glance at the measurements will show that in most cases the long dimension of the grain exceeded the size of the opening in the screen. The question as to whether this fact might affect passage through the screen may be raised. Measurements of grains in many samples which actually passed the 60 mesh screen show grains with long dimensions equally as great. Therefore it seems that the above fact does not materially affect the passage through the screen.

Another matter of importance to be considered in the above comparison of grain sizes, is the question of whether or not the largest grains might have been lost, even in the panning process. Tourmaline and zircon make up the greater percentage of the heavy minerals. The tourmaline grains are from two to ten times as large as those of zircon. Since the specific gravity of tourmaline (2.98-3.2) is much nearer that of quartz (2.65) than is zircon (4.68-4.70), and since the size of the tourmaline grains also approaches that of the quartz grains, it appears likely that the larger grains of tourmaline will tend to remain associated with the quartz and be lost. But even if such was the case, it does not appear logical that all of the large grains of tourmaline would be lost in panning. Certainly the percentage of the large grains present is very small, or more than two such grains would have been encountered in the four slides which

were panned and later measured. That concentration of these sandstones by screening through a 60 mesh screen is sufficiently accurate for most scientific purposes there remains little doubt. It is believed that concentration by screening will result in fewer grains being lost than when the panning process is used.

As has been noted above, all of the material which passed the 60 mesh screen was then separated by means of acetylene tetrabromide; the material retained on the screen being discarded. With most of the samples 250 cc. of the original crushed sandstone was screened, although as was later found 100 cc. would have been sufficient for the great majority of cases, and difficulties which later developed would have been avoided.

The screened material was in practically all cases to a greater or less extent coated with iron oxide. To remove this coating the sample was boiled in a 50 per cent solution of hydrochloric acid for a period of time varying from twenty to forty minutes depending upon the amount of iron oxide present.

When the destructive forces to which the minerals in these sandstones have already been subjected in nature is considered, it is seen that there is little likelihood that they will be destroyed by this treatment in acid. Of course pyrite would be dissolved, but since it is a secondary mineral, and is known to exist in all of the sandstones of this region, its retention would be of little diagnostic value. Magnetite, also, if present, would have been lost. This ubiquitous mineral also probably has little value for discriminatory purposes. Other minerals which may be expected would suffer little or no change in this acid treatment.

After the removal of the oxide was complete the samples were thoroughly washed by decantation to remove all traces of acid, after which they were set upon the hot plate or sand bath to dry. When the sand was dry it was pure white, and was then ready for the final separation of the quartz from the detrital heavy minerals.

For this, acetylene tetrabromide with specific gravity of 2.94 was used. In separating the first samples six inch evaporating dishes were used. They were partially filled with acetylene tetrabromide and the sand poured on top. The mixture was then stirred every few minutes for a period of an hour or more. This stirring was carried on in such a way that once the grains had settled to the bottom they were not again brought back up into the mixture. After stirring was completed, from two to three hours, often longer, was allowed for complete separation to take place. Then the lighter mate-

rial was simply decanted, leaving the heavy grains on the bottom of the dish. These were subsequently collected and washed onto filter paper with benzene. They were then washed three to five times with benzene, and after drying were placed in envelopes and filed for future petrographic study.

While the above method gave excellent crops of heavy minerals, more time and painstaking care were necessary than when the separation was done with simple separatory funnels. These were of the type with very steep conical sides, in order to prevent undue retardation of the slowly settling grains. They were arranged in a battery of ten, although more would have been better. After they were filled about two-thirds full of liquid, the sand was introduced and thoroughly stirred every fifteen or twenty minutes for a period of about three hours. They were then allowed to stand, without stirring, for a period of several hours, usually over night.

When the heavy minerals had collected at the stop cock of the funnel they were drawn off onto a filter paper and treated in the same manner as those which had been separated in evaporating dishes. It is doubtful if a complete separation can ever be affected, due to the fact that the very small heavy grains will tend to adhere to larger quartz grains and will thus be prevented from sinking. The completeness of the separation is directly related to the number of times the mixture is stirred.

In all of the above processes the time element must be considered. The time taken depends largely upon the standardization of the processes, after preliminary experiments have shown what treatment gives best results.

Petrographic Study

There are two methods of mounting the grains for petrographic study: (1) Temporary mounts in index of refraction liquids; or (2) permanent mounts in Canada balsam. Both methods have advantages and both were used in this study. Permanent mounts can be filed and referred to any future time, although it is practically impossible to positively identify some unknown grains which may be discovered in such a mount. Therefore temporary mounts in liquids of known index of refraction are practically indispensable. A method used to good advantage, consisted of first studying the material under a low power binocular microscope, and isolating those grains that appeared to be alike. Then four or five of these grains were transferred to a liquid of known index of refraction and studied un-

der the polarizing microscope. When it was necessary to transfer them to another liquid the cover glass was removed and the slide again placed under the lower power binocular microscope, and with a fine needle the grains were isolated from the liquid and collected on one end of the slide, where they were washed with a drop or two of xylol. When the xylol had evaporated they were transferred to another slide with a fine camel's hair brush. This process was repeated as many times as was necessary. The above procedure may seem slow and laborious, but it is only necessary to perform it once, in most cases, and after that when the mineral grain is encountered it can be recognized almost at sight.

In most cases there was a sufficient number of grains to make more than one slide. It had been planned to mount one slide of the mineral grains in Canada balsam and retain the remainder for further study in liquids of known index of refraction, in case this became necessary after studying those in the permanent mount. Such a procedure was carried out except in about ten cases, where the total was mounted permanently. The minerals in the permanent slides were determined, counted and the percentages of each calculated. A graphical chart was made showing the comparison of percentages in the various samples. Some very interesting information was revealed by a study of this chart.

In most cases where the total material (Samples No. 40 to 50) was mounted, the percentage of zircon exceeded that of tourmaline, while in the great majority of other cases (those in which only a part of the material was mounted) the ratio between zircon and tourmaline was reversed. Investigation into the cause of this discrepancy revealed additional information.

A study of the two minerals showed that the tourmaline grains were not only much larger, but were also better rounded than those of zircon. The cause of the variation in ratio was very apparent. When the minerals were filed after separation, they, as already indicated, were preserved on filter paper. At the time of mounting, the grains were allowed to roll from the center of the paper to the outer margin, where a part was shaken onto the slide and the remainder again filed. It will be readily seen that since the tourmaline grains were larger and better rounded than the zircon grains, they, along with a few of the better rounded zircons reached the outer margin first, and were thus, more or less segregated from the smaller and more angular minerals, and as such appeared in the first slide mounted. Upon mounting a few slides of the remaining material, and

studying them under the microscope, their content, in most instances, proved to be made up largely of small zircon and leucoxene grains with only a few of tourmaline.

A few samples have been selected more or less at random to show the above effect, and the results are tabulated in the following table:

COMPARISON OF FIRST AND SECOND MOUNTS

	Sample No. 27		Sample No. 109		Sample No. 53		Sample No. 66	
	Part mtd.	All mtd.	Part mtd.	All mtd.	Part mtd.	All mtd.	Part mtd.	All mtd.
Tourmaline	40%	25%	70%	25%	90%	32%	10%	8%
Zircon	50%	70%	25%	70%	5%	50%	65%	80%
Leucoxene	10%	5%	5%	5%	5%	18%	25%	12%
Blue Tour.	Pres.	Pres.	Pres.	Pres.	Pres.	Pres.	Pres.	Pres.

The first column represents slides in which only a part of the material from each sample was mounted, the second column the total "crop". In every case the percentage of tourmaline was reduced while that of zircon was increased, in most cases the change being very great. The percentage of leucoxene was not greatly affected, since these grains vary more in size and angularity than do those of tourmaline and zircon. The above incident in technique reveals an important caution that must be exercised in such studies, and it is hoped that the above discussion will be of value to future workers.

After this error was discovered it became necessary to mount all of the remaining material and recalculate the ratios of one mineral to another.

Difficulty in obtaining the relative percentages of the minerals present was now encountered, since the first slide mounted contained most of the tourmaline and larger zircon grains, while the second slide contained chiefly the small, more angular zircon and leucoxene grains. This could have been easily overcome by counting all of the grains had the number been small, but in many cases the total number was well over 5,000 and the time available would not permit such large counts to be made. Even though it had, such a procedure would have been a stupendous task. The only choice left was to estimate as closely as possible the relative number of grains present. This was accomplished in the following manner.

Since there was no way of knowing exactly what part of the total was in each slide, both were taken, and actual counts made in various parts of each. Estimates were then made on the number of grains present in each slide and the counts weighted accordingly. Checks on the accuracy of the estimates were made by counting the total number of grains in two samples. These were selected, because the total number of grains was comparatively small, but even so sample

No. 5 contained 4285 grains and No. 50 contained 1816. The relative percentages were first estimated in the manner indicated above, and then actual counts were made. A glance at the chart below shows that in no case does the estimate differ more than ten per cent from the actual count, and the average error was five per cent. An error this small would have little effect in a problem of this nature, although it is possible that it may be somewhat greater in cases where the total number of grains was unusually large.

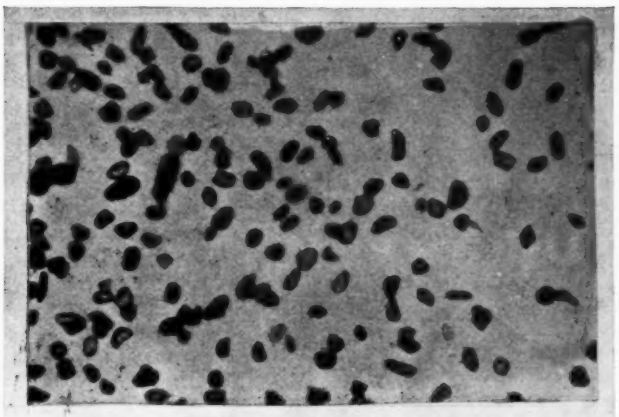
COMPARISON OF COUNTS AND ESTIMATES OF GRAINS IN SLIDES

	Sample No. 5			Sample No. 50		
	Estimate	Count	Error	Estimate	Count	Error
Tourmaline	25%	23%	2%	63%	58%	5%
Zircon	60%	70%	10%	30%	36%	6%
Leucoxene	15%	7%	8%	7%	6%	1%
Blue Tour.	Pres.	Pres.		Pres.	Pres.	

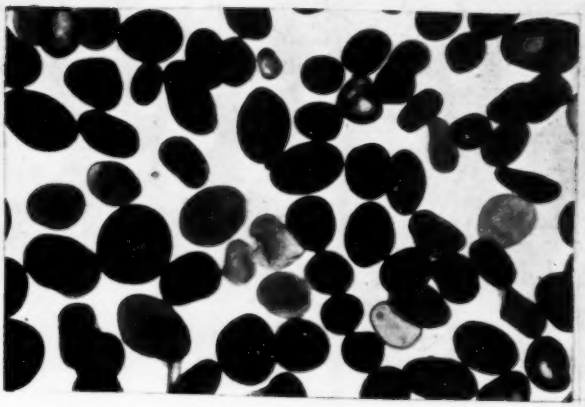
RESULTS

Zircon was the most conspicuous mineral grain in most cases. The most common species was colorless, although a few yellow-brown grains were encountered in practically every sample. Inclusions within the grains are common, in many cases producing a dusky appearance. The grains vary considerably in form, from very well rounded to almost perfect euhedral crystals. The larger the size, the more perfect the rounding. Some of the very largest grains were almost spherical, while the very smallest ones showed well developed prismatic and pyramidal forms. Of course the great majority of the grains lie between these two extremes, but sharply angular fragments are very rarely encountered. As already stated the size of the grains varies greatly, but rarely are they as large as those of tourmaline. Some of the largest are .15 to .18 mm. in diameter, while the smallest are 0.02 mm. or less in size, with the average probably about 0.8 to .12 mm. A characteristic grain of zircon is often well rounded, with one dimension two to three times the other. It is possible that mineral grains of xenotime are present and have not been differentiated from those of zircon.

In general the next most frequent mineral grain was tourmaline. The most important feature exhibited by this mineral was the high degree of rounding. No grains were observed that showed the least resemblance to a crystal face. Many show a strong elongation parallel to the c-axis, as shown by absorption, but the rounding is always



A. SUBANGULAR TO ANGULAR GRAINS ~CHIEFLY ZIRCON ×40



B. ROUNDED GRAINS CHIEFLY TOURMALINE × 40

good. Spherical grains, although not very common, do occur, and from them the best interference figures are obtained. Several colored varieties are present, among which are brown, brownish-yellow, black, green, blue, and possibly a few colorless grains. Inclusions are very common. No attempt was made to separate the varieties, except in the case of the blue grains. Because they were conspicuous and relatively few in number, it was a simple matter to note their occurrence. In general the tourmaline grains are much larger than the zircon grains, in many cases the long dimension of the grain being .2 mm. or more.

A third mineral present is leucoxene. This occurs in rounded or irregular grains, white to brownish white in reflected light. A rough, pitted, porous surface is also characteristic. Many of the grains show a rudely triangular shape with slightly rounded edges. Some difficulty was experienced in positively identifying the mineral under the microscope, and finally a sample (No. 84) which showed a large percentage of the opaque mineral was tested chemically for titanium. The test was decidedly positive, and upon the basis of this test, coupled with the microscopic characteristics, the mineral was called leucoxene. The size of these grains is very variable, some being as large as those of tourmaline while the great majority are smaller, probably averaging smaller than the zircon grains.

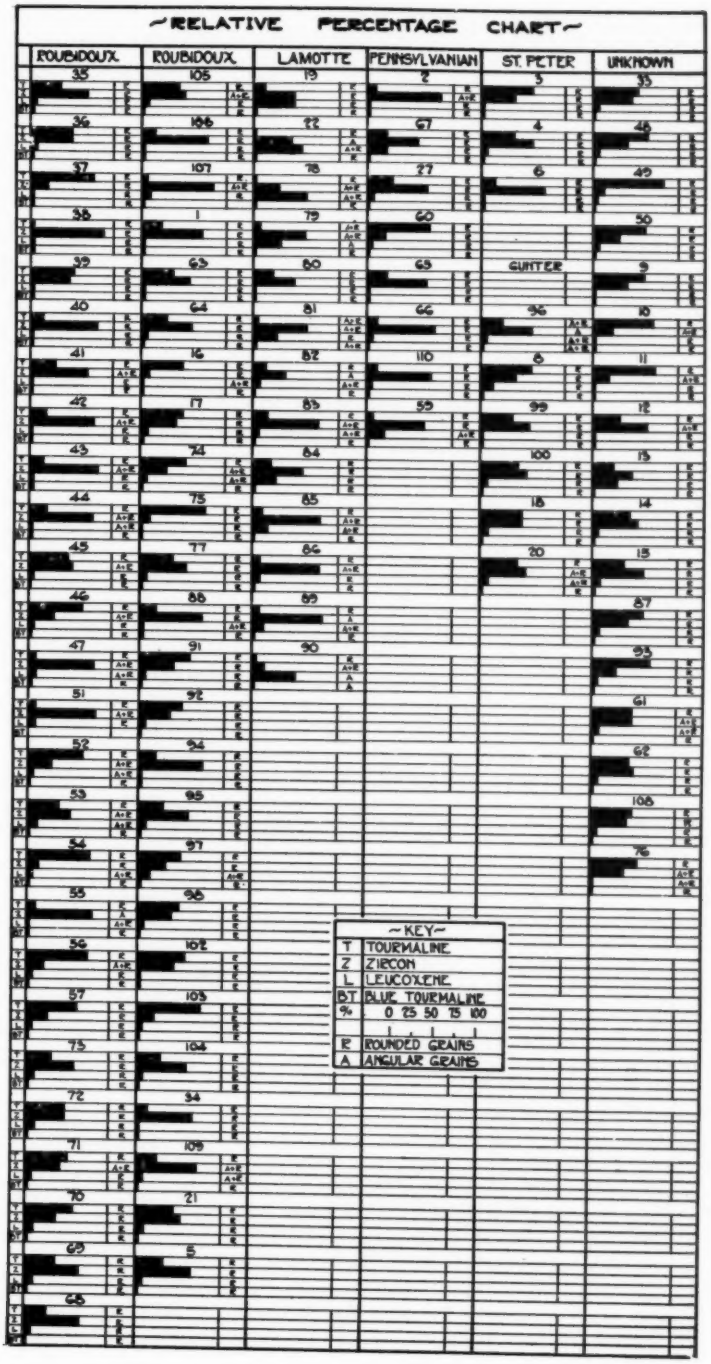
Another mineral which is found in some samples in great abundance is anatase. It is transparent to opaque, often showing a yellowish tinge, with euhedral form. Most of the crystals are square tablets, lying on the basal pinacoid. It is presumably a secondary mineral derived in situ since the well developed euhedral forms are found associated with well rounded tourmaline and zircon grains. This mineral was noted in five samples, although it is possible that it may be present in others. (See table below).

PERCENTAGE OF ANATASE

	Sample No. 16 Roubidoux	Sample No. 34 Roubidoux	Sample No. 80 Lamotte	Sample No. 82 Lamotte	Sample No. 90 Lamotte
Anatase	25%	10-15%	33%	50%	45%

In making the relative percentage chart anatase is not shown because of the relatively few samples in which it was observed.

At the same time the mineral identification was made the rounding of the grains was also noted. Two photomicrographs (plate 8) were


~RELATIVE PERCENTAGE CHART~
ROUBIDOUX
ROUBIDOUX
LAMOTTE
PENNSYLVANIAN
ST. PETER
UNKNOWN
GUNTER
~KEY~
T TOURMALINE
Z ZIRCON
L LEUCOXENE
BT BLUE TOURMALINE
% 0 25 50 75 100
R ROUNDED GRAINS
A ANGULAR GRAINS

taken to show the degree of rounding. Grains are designated as being rounded (R) and angular (A).

This method of notation has been used to give only a rough approximation of the degree of rounding. Grains which are designated as rounded really show rounding to a high degree, while those grains which have been called angular include a rather wide range, from a few angular, to subangular, and euhedral grains. Most of those grains which have been designated as angular are possibly subangular. The idea was to show that some grains are not as well rounded as others. No attempt was made to obtain a quanitative estimate on round and angular grains.

Since there were only three chief minerals present in the sands examined and since they were present in all of the samples, the method of graphical representation was simple. It gives at a glance the comparison of any one sample with another, either in one of the sandstones or in all of them.

The relative percentage chart (plate 9) indicates only the percentage of the mineral grains present, as no attempt was made to plot the percentages of the minor varieties of mineral species in the different sands.

A careful study of this percentage chart shows the data which is indicated in plate 10.

Summary of Results

Summarizing the results, the following are outstanding:

1. The presence of the same mineral suite—tourmaline, zircon, leucoxene—in each of the five sandstone formations.
2. The high degree of rounding exhibited by the minerals, especially tourmaline, in practically every sample from all of the formations.
3. A lack of constancy in the relative percentages of the various minerals, either in one formation or in the group as a whole.

Conclusions

From the afore mentioned results it is seen that it is not possible to discriminate between any of the five sandstones, on the basis of the heavy mineral content alone, since the same minerals are present in each of them, and since the relative percentages are as variable within any single formation as they are throughout the entire group of formations.

TABLE SHOWING RESULTS

ROUBIDOUX	PENNSYLVANIAN	GUNTER	ST. PETER	LAMOTTE
TOURMALINE AND ZIRCON DOMINANT	TOURMALINE AND ZIRCON DOMINANT	TOURMALINE AND ZIRCON DOMINANT	TOURMALINE AND ZIRCON DOMINANT	TOURMALINE AND ZIRCON DOMINANT
30 Cases Zircon > Tourmaline 19 Cases Tourmaline > Zircon 2 Cases Tourmaline = Zircon	7 Cases Zircon > Tourmaline 1 Case Tourmaline > Zircon	4 Cases Zircon > Tourmaline 1 Case Tourmaline > Zircon 1 Case Tourmaline = Zircon	2 Cases Zircon > Tourmaline 1 Case Tourmaline > Zircon	13 Cases Zircon > Tourmaline
LEUCOXENE Present In All Trace To 20%	LEUCOXENE Present In All Trace To 25%	LEUCOXENE Present In All Trace To 15%	LEUCOXENE Present In All Small Percentages	LEUCOXENE Present In All Trace To 50%
BLUE TOURMALINE Present In All Cases Very Small Percentages	BLUE TOURMALINE Present In All Cases Very Small Percentages	BLUE TOURMALINE Present In All Cases Very Small Percentages	BLUE TOURMALINE Present In All Cases Very Small Percentages	BLUE TOURMALINE Present In All Cases Very Small Percentages
All Tourmaline Well Rounded Zircon and Leucoxene Rounded and Angular	All Tourmaline Well Rounded Most Zircon and Leucoxene Well Rounded Few Zircon and Leucoxene Rounded and Angular	All Tourmaline Well Rounded Zircon and Leucoxene Rounded and Angular	All Tourmaline Well Rounded All Others Nearly As Well Rounded	All Tourmaline Well Rounded Many Zircon and Leucoxene Rounded and Angular
No Constancy Of Percentages Geographically or Stratigraphically	No Constancy Of Percentages Geographically Not Determined Stratigraphically	No Constancy Of Percentages Geographically Not Determined Stratigraphically	No Constancy Of Percentages Geographically Not Determined Stratigraphically	No Constancy Of Percentages Geographically Not Determined Stratigraphically

To say that any one of the unknown samples is Lamotte, Gunter, Roubidoux, St. Peter, or Pennsylvanian from the data so far discovered concerning the heavy mineral content would be merely a guess.

The minerals present in these particular sandstones represent exceptionally stable varieties. This may have some bearing on the determination of the source from which the sediments were derived. As suggested by Milner[7], the presence of this particular suite of heavy minerals, to the exclusion of all others, implies a derivation of the formations from pre-existing sediments, from which less stable varieties had largely been eliminated by weathering and abrasion. Also the very remarkably perfect rounding of minerals as resistant as these is suggestive of more than one cycle of erosion and deposition. Of course transportation from a very distant source would also tend to produce a high degree of rounding.

The similarity in heavy mineral suites, and the corresponding variation in ratios between the species, suggests that the sandstones studied were probably derived from a common ultimate source. The Pennsylvanian, which in this region is the very basal sand, was probably derived from the re-worked material of all these older sandstones.

Further intensive petrographic studies might reveal differences in the mineral species, which would in turn afford a basis for discrimination. Varieties may be present in one formation and not in another. A careful study of the inclusions within the mineral grain might be helpful. Careful screening might show the size of the heavy minerals in one formation to be different from those in another.

If the heavy minerals of these five formations could be discriminated with any certainty, the method would be very helpful in correlating the isolated patches of sandstone in the Ozarks. It appears rather doubtful, however, whether further studies would reveal differences great enough to enable discrimination between the sands, if the sediments were derived from a common source, and from pre-existing sediments as suggested above.

[7] Milner, H. B., Introduction to the Study of Sedimentary Petrography, p. 106, 1922.

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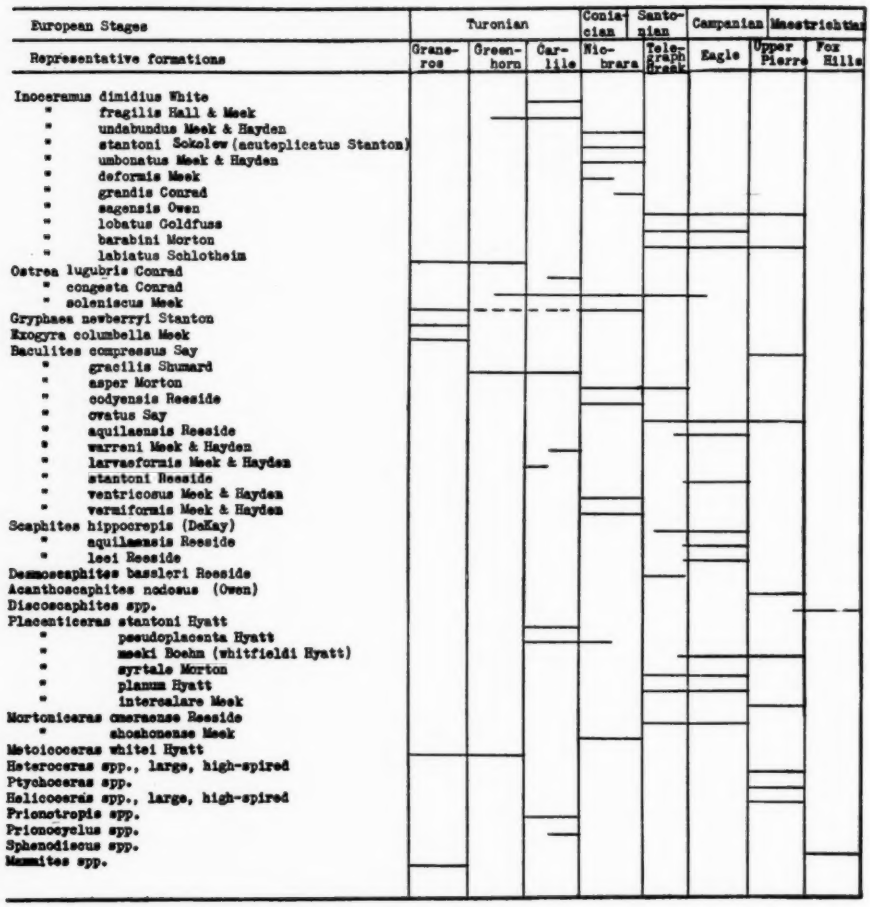
VERTICAL RANGE OF THE MORE COMMON SPECIES OF THE UPPER CRETACEOUS IN THE WESTERN INTERIOR

By GEO H. HANSEN

(Adapted from Reeside, John B., Jr.,—U. S. Geological Survey Professional Paper 134, pp. 11 and 49, also Oral Communication with Dr. Reeside)



BRACKISH-WATER PLIOCENE DIATOMS FROM THE ETCHEGOIN FORMATION OF CENTRAL CALIFORNIA

By G. DALLAS HANNA and WILLIAM M. GRANT
California Academy of Sciences

The Etchegoin formation is a thick series of sediments in the San Joaquin Valley, California. Outcrops are numerous on the west side of the valley and the paleontology is well known in so far as mollusks and echinoderms are concerned. Formerly the formation was placed in the upper Miocene but geologists now generally agree that it is Pliocene. The lower part is supposed to be lower Pliocene and the upper part middle or upper Pliocene. The formation usually lies directly on Miocene sediments equivalent in age to the Santa Margarita or Monterey formations. Above the Etchegoin, lies the Tulare (freshwater) formation with apparently continuous sedimentation and some alternation between. The Tulare formation has been considered to be upper Pliocene.

The collection of diatoms studied in the present connection came from the extreme northwest end of the Kettleman Hills, Fresno County, California. In this region there is a long anticlinal uplift trending northwest and southeast. The Tulare and some hundreds of feet of the Etchegoin have been eroded from the axis of this structure, leaving many excellent sections exposed. The base of the Tulare is easily traced, being a stratum of fairly coarse, more or less loosely consolidated, buff sand with numerous distinctive fossils such as *Anodonta, Amnicola* and peculiar bony nodules, which are supposed to have been parts of the skeletons of fishes.

Ten to thirty feet below this layer there is an oyster deposit containing many *Ostrea lurida.* The diatom-bearing shale, a fine grained, pale gray, clay shale lies between these two well-marked molluscan zones. In some places the shale is composed largely of quartz sand

so fine that attempts have been made to use it for clay, fuller's earth, etc. At the locality here being considered there is some volcanic ash mixed with the sand and after proper cleaning and concentration, diatoms are found to be fairly abundant. However, the material cannot be considered to be "diatomite" at all because the actual percentage of organisms is very small.

The locality is entered in the records of the California Academy of Sciences as follows:

Loc. 696. Pale gray, fine grained, clay-shale from sec. 29, T. 21 S. R. 17 E. M. D. M., north end of Kettleman Hills, Fresno County, California; G. D. Hanna, Coll., March, 1926. Shale immediately overlies a thick stratum containing *Ostrea lurida;* the only fossils found in shale were brackish-water diatoms.

The number of species of diatoms present is very small and they prove conclusively the existence of brackish-water conditions. Below the oyster deposit where the collection was obtained, characteristic Etchegoin Mollusca and Echinodermata are found.

Although it might be expected that erosion of upper Miocene, diatomaceous shales round about would cause some of their distinctive species to be deposited with the Etchegoin sediments, thus far no evidence of such action has been detected in the collection.

This is apparently the first time diatoms have been recorded in the Etchegoin with the exception of sundry scattered valves of *Coscinodiscus* taken from well-samples in the southern end of the valley. Usually these are more or less pyritized or otherwise modified and may be reworked Miocene forms.

The living freshwater diatoms of the region have not been criti-

EXPLANATION OF PLATE 11

FIG. 1.—*Biddulphia edwardsii* (?) Febiger; high focus. Plesiotype, No. 3,063 (Calif. Acad. Sci), ×1,100; length, .062 mm.; width .040 mm.

2.—*Biddulphia edwardsii* (?) Febiger; low focus. Plesiotype, No. 3,063 (Calif. Acad. Sci.), ×980.

3.—*Biddulphia edwardsii* (?) Febiger; side view. Plesiotype, No. 3,064 (Calif. Acad. Sci.).

4.—*Campylodiscus echeneis* Ehrenberg. Plesiotype, No. 3,065 (Calif. Acad. Sci.), ×350; width, .1448 mm.; height, .1448 mm., in view shown in photograph.

5.—*Campylodiscus echeneis* Ehrenberg. Plesiotype, No. 3,066 (Calif. Acad. Sci.), ×600; greatest dimension of fragment shown, .0840 mm. This specimen has very sparse markings.

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cally studied, the only records with which we are familiar having been made by C. S. Elmore in "The Diatoms of Nebraska"[1].

In this work may be found listed a considerable number of species from the San Joaquin River. They have little of interest in the present connection.

Most of the species found in this Pliocene deposit have been previously described; this might be expected in view of the thoroughness with which the diatoms of the world have been studied. Adequate illustrations, however, are not available to many students and for this reason photographs of all have been prepared for the present paper.

Because of the gradual change from marine conditions of the Etchegoin period to the lacustrine of the Tulare there is considerable difficulty in placing the plane of demarcation; the subject is one about which there may easily be much difference of opinion. Continuous sedimentation seems unquestionable and the change from salt water to lake deposition was not sudden. One way to escape difficulty is to apply the name Etchegoin up in the series to the top of the last layer laid down in marine or brackish water. Obviously some layers bearing freshwater fossils will fall below this point and whether they should be called "Etchegoin" or "Tulare" does not need a decision at this time.

With this as a basis of separation of the two formations, the diatoms dealt with herein came from the extreme upper portion of the Etchegoin.

BIDDULPHIA EDWARDSII (?) Febiger

Plate 11, figs. 1, 2, 3,

Biddulphia edwardsii FEBIGER, in VAN HEURCK, Syn. Diat. Belgique, 1881, pl. 100, figs. 9, 10; California.—GRUNOW, Denk. Akad. Wiss. Wien, vol. 48, 1884, p. 57, pl. 2, fig. 20.—BOYER, Proc. Acad. Nat. Sci. Philadelphia, 1900, p. 701.—MANN, Cont. U. S. Nat. Herb., vol. 10, 1907, p. 301.

Diatoms similar to the one figured herewith are fairly common in the Kettleman Hills deposit. They lack the secondary spines scattered over the disk shown in Van Heurck's original figures and in this respect they agree more closely with *B. roperiana* Greville[2]. However, the later is more pointed on the ends. The present collection might be considered to represent an undescribed species were it not for the fact that *B. edwardsii* is said to be exceedingly variable in

[1] Elmore, C. S. The Diatoms (Bacillaroideae) of Nebraska. *Univ. of Neb. Studies*, vol. 21, no. 2 (Oct. 1921), pp. 22-214, pls. 1-23, 861 figs.

[2] *Trans. Micr. Soc.*, vol. 7, n. s. (1859), p. 163, pl. 8, figs. 11-13.

most characters. Not having a very clear conception of what these variations are it seemed best to make the identification as given above.

CAMPYLODISCUS ECHENEIS Ehrenberg

Plate 11, figs. 4, 5

Campylodiscus echeneis EHRENBERG, Abh. Akad. Wiss., Berlin, 1840, p. 208.—EHRENBERG, Mikrog., 1854, pl. 10, group 1, fig. 1, group 2, fig. 21.—SCHMIDT, Atlas, Diat., pl. 54, 1877, figs. 3, 6.—VAN HEURCK, Syn. Diat. Belg., 1881, pl. 76, figs. 1, 2.—WOLLE, Diat. N. Amer., 1890, pl. 73, figs. 5, 7.—DEBY, Anal. *Campylodiscus*, 1891, p. 43, pl. 9, fig. 49.—VAN HEURCK, Treat. Diat., 1896, pl. 14, fig. 600.

A large and coarsely marked *Campylodiscus* occurs occasionally in the Kettleman Hills deposit. The valves are often broken but the characters are readily ascertained. The species *echeneis* is essentially a marsh and brackish-water diatom and is said to be highly variable; the available figures show this to be true. While no figure was found with which our specimens agree in detail it is believed the identification is warranted; in fact we have found no two specimens alike. The markings are exceedingly coarse and often a blank area in the center is suggestive of *C. clypeus*. However, the grouping of the radial lines of beads in the usual *Surirella* manner in that species has not been noticed in the specimens we have seen.

COCCONEIS LINEATA Ehrenberg

Plate 12, figs. 1, 2

Cocconeis lineata EHRENBERG, Poggendorf's Annal., 1839.—EHRENBERG, Mikrog., 1854, pl. 1, group 1, fig. 12 *a*; pl. 6, group 1, figs. 40 *a*, *b*; pl. 39, group 3, fig. 11.—VAN HEURCK, Syn. Diat. Belg., 1880-1881, pl. 30, figs. 31, 32.—WOLLE, Diat. N. Amer., 1890, pl. 33, figs. 6, 7.—VAN HEURCK, Treat. Diat., 1896, pl. 8, fig. 342.—SCHMIDT, Atlas Diat., pl. 192, fig. 35.

This well known and widely distributed brackish-water diatom is common in the Kettleman Hills Pliocene deposit. Variation in size is great as the accompanying figures show, but the form of sculpture is fairly uniform. Except with high aperture, immersion objectives, the markings appear as wavy longitudinal lines. Properly resolved, the lower valves are marked as the photographs display. The upper valves are similar but have a raphe and broad marginal zone.

CYMBELLA GASTROIDES Kützing

Plate 12, fig. 3

Cymbella gastroides KÜTZING, Bacill., 1844, p. 79, pl. 6, fig. 4 *b*.—VAN HEURCK, Syn. Diat. Belg., 1880-1881, pl. 2, fig. 8.—WOLLE, Diat. N. Amer. 1890, pl. 7, figs. 4, 5.—VAN HEURCK, Treat. Diat., 1896, p. 146, pl. 1, figs. 35, 36.

The presence of such freshwater forms as this in a deposit containing normally brackish-water-dwelling forms is not unusual elsewhere. The species is rare in the Kettleman Hills deposit.

EPITHEMIA WESTERMANNI (Ehrenberg)

Plate 12, fig. 4

Eunotia westermanni EHRENBERG, Abh. Akad. Wiss. Berlin, 1836, p. 130.—EHRENBERG, Infus., 1838, p. 100, pl. 14, fig. 6.—EHRENBERG, Mikrog., 1854, pl. 8, group 1, fig. 1; pl. 9, group 1, fig. 23.

Epithemia westermanni (EHRENBERG), KÜTZING, Bacill., 1844, pl. 5, fig. 12.—VAN HEURCK, Syn. Diat. Belg., 1880-1881, pl. 31, figs. 8, 9.—VAN HEURCK, Treat. Diat., 1896, p. 295, pl. 9, fig. 347; [as a var. of *E. turgida*].

Van Heurck's interpretation of this species is here accepted. *E. turgida*, which probably intergrades, is shown as a more slender form with capitate ends. The habitat of the two forms is said to be differ-

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EXPLANATION OF PLATE 12

FIG. 1.—*Cocconeis lineata* Ehrenberg. Plesiotype, No. 3,068 (Calif. Acad. Sci.), ×2,100; length, .0372 mm.; width, .0213 mm.

2.—*Cocconeis lineata* Ehrenberg. Plesiotype, No. 3,069 (Calif. Acad. Sci.), ×1,450; length, .0455 mm.; width, .0244 mm.

3.—*Cymbella gastroides* Kützing. Plesiotype, No. 3,070 (Calif. Acad. Sci.), ×840; length, .0974 mm.; width, .0264 mm.

4.—*Epithemia westermanni* (Ehrenberg). Plesiotype, No. 3,071 (Calif. Acad. Sci.), ×930; length, .0832 mm.; width, .0230 mm.

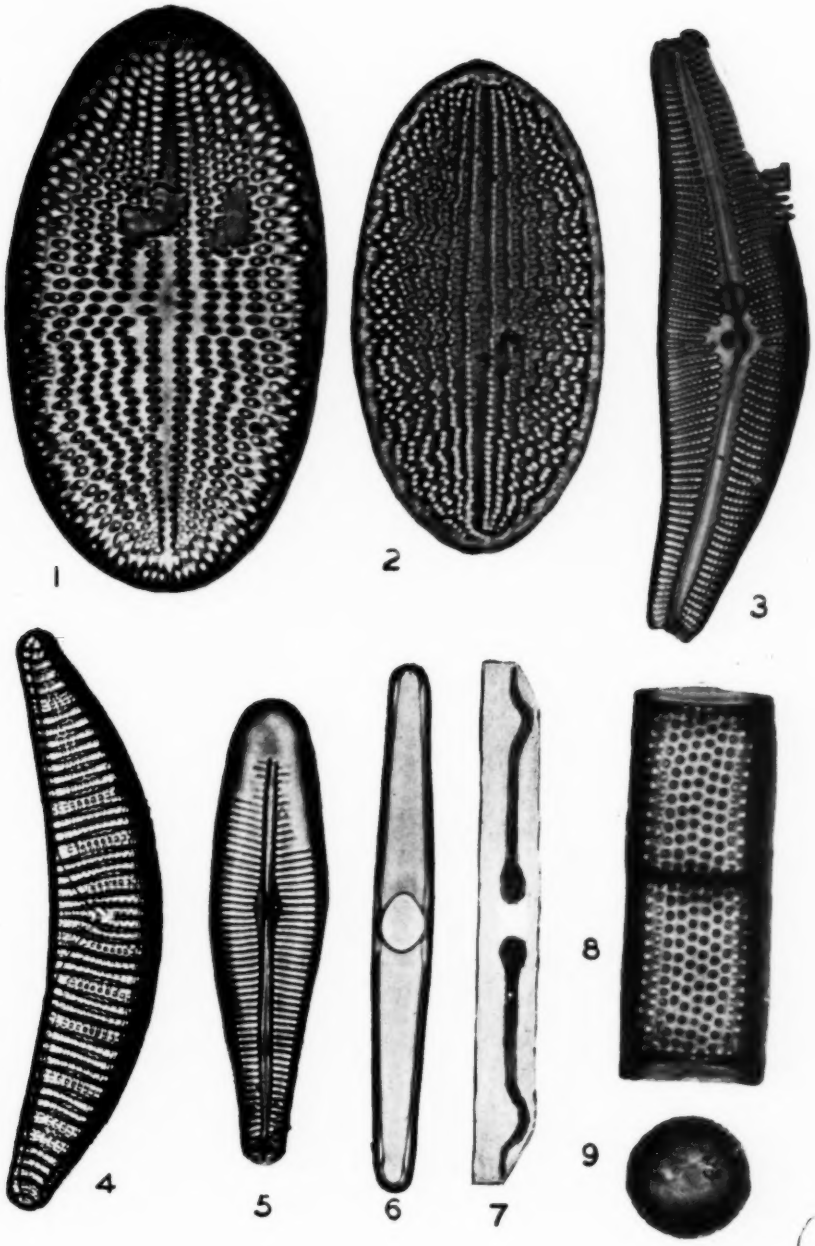
5.—*Gomphonema herculeanum* Ehrenberg. Plesiotype, No. 3,072 (Calif. Acad. Sci.), ×1,260; length, .0500 mm.; width, .0137 mm.

6.—*Grammatophora maxima* (?) Grunow. Plesiotype, No. 3,073 (Calif. Acad. Sci.), ×1,075; length .0658 mm.; width, .010 mm.

7.—*Grammatophora maxima* (?) Grunow; side view. Plesiotype, No. 3,074 (Calif. Acad. Sci.).

8.—*Melosira granulata* (Ehrenberg). Plesiotype, No. 3,077 (Calif. Acad. Sci.), ×1,580; length, .0334 mm.; diameter, .0128 mm.; side view of specimen to show markings.

9.—*Melosira granulata* (Ehrenberg). Plesiotype, No. 3,077 *a* (Calif. Acad. Sci.), ×1,580; diameter, .0128 mm.; end view.



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ent, *turgida* living in fresh water, *westermanni* in brackish. Specimens similar to the one figured herewith are common in the Kettleman Hills deposit.

GRAMMATOPHORA MAXIMA (?) Grunow

Plate 12, figs. 6, 7

Grammatophora maxima GRUNOW, Verh. Zool. Bot. Ges. Wien, vol. 12, 1862, p. 416, pl. 8, fig. 5.—VAN HEURCK, Syn. Diat. Belg., 1881, pl. 53 *bis*, figs. 12, 13.—MANN, Cont. U. S. Nat. Herb., vol. 10, 1907, p. 320.

The presence of this *Grammatophora* in the Kettleman Hills deposit was hardly to be expected, yet it occurs frequently. In shape it agrees very well with the figures of *maxima* in the literature. The species is well known to have fine markings yet they are not ordinarily very difficult of resolution. In the case of the Kettleman Hills specimens, however, the finer structure could not be determined by any available optical equipment. Valves mounted in "Hyrax" of refractive index 1.80 appeared perfectly blank with critical illumination and full 1.40 numerical aperture. Under the same conditions the markings of *Amphipleura pellucida* were easily resolved into beads. Because these markings could not be determined in the *Grammatophora* the specific identification must remain in doubt for the present.

GOMPHONEMA HERCULEANUM Ehrenberg

Plate 12, fig. 5

Gomphonema herculeanum EHRENBERG, Monatsber. Akad. Wiss. Berlin, 1845, p. 78; Mikrog., 1854, pl. 35A, group 7, figs. 12, 13; pl. 37A, fig. 9.—VAN HEURCK, Syn. Diat. Belg., 1880-1881, pl. 23, fig. 2.

Gomphoneis herculeanum (EHRENBERG), SCHMIDT, Atlas Diat., pl. 215, 1899, figs. 4-14; pl. 233, 1902, figs. 1, 2.

Schmidt's fig. 11, drawn from a New York specimen agrees almost exactly with the specimens found in the Kettleman Hills Pliocene deposit. That figure he has labelled "var. *robusta*" Grunow[3], but it seems doubtful if, in a large series, the subspecies can be retained. The species is not common in the Kettleman Hills material; the speciman figured is a frustule, the upper part of one end of one valve having been broken in cleaning.

[3] See Grunow, Algae und Diatomaceen aus dem Kaspischen Meere. In Dr. O. Schneider's *Naturwiss. Beit. Kennt. Kaukasuslander*, vol. 9 (1878), p. 110, pl. 3, fig. 3.

HYALODISCUS SCHMIDTII Frenguelli

Plate 13, figs. 1, 2, 3, 4

Hyalodiscus schmidtii FRENGUELLI, Bol. Acad. Nac. Cienc. Cordoba, vol. 29, 1926, p. 73, pl. 9, figs. 4, 5; estuary of Rio de la Plata.

This species is the most common diatom in the Kettleman Hills deposit. The central hyaline disk has the usual irregular border and is often marked with large blotches as in the specimen photographed; these blotches may be the result of attachment of the valve in life or may have resulted from some process in the preservation of the silica in these strata; they appear to be adhering foreign particles but are not; they are often missing. The disk is marked with faint undulations, barely visible in styrax with oblique blue light and numerical aperture of 1.20. Under the same conditions the annular zone is found to be marked with excessively fine radiating lines; these could not be resolved into beads with this aperture. Under lower magnification or less aperture the outer zone appears to be marked with irregularly shaped beads and blotches, arranged in no definite order. This is one of the few species of *Hyalodiscus* in which the outer zone is darker than the central area. Frenguelli's original figure shows the outer zone marked with radial lines, perhaps a little coarser than in our specimens, and with dark beads scattered here and there. It therefore does not agree with our specimens in every particular but the differences hardly seem sufficient to warrant separation at this time.

MELOSIRA GRANULATA (Ehrenberg)

Plate 12, figs. 8, 9

Gallionella granulata EHRENBERG, Abh. Akad. Wiss. Berlin, 1841, p. 127.—EHRENBERG, Mikrog., 1854, pl. 33, group 2, fig. 15.

Melosira granulata (EHRENBERG) VAN HEURCK, Syn. Diat. Belg., 1880-1881, pl. 37, figs. 9-12.—WOLLE, Diat. N. Amer., 1890, pl. 57, figs. 7-9.—SCHMIDT, Atlas Diat., pl. 181, 1893, figs. 57, 58, 66.

This species is common in the Kettleman Hills Pliocene; apparently it was able to live in the waters then present but it did not exist to the exclusion of almost all other diatoms here as it did in the great inland lakes of the Miocene, Truckee and Esmeralda in Nevada and several in Oregon and California. Unquestionably the seventeen subspecific or varietal names based on variations of this protean form are too large a number but which should be discarded remains to be determined when some of the lake deposits mentioned are studied.

NAVICULA MARINA Ralfs

Plate 13, figs. 6, 7; plate 14, fig. 1

Navicula marina RALFS, in PRITCHARD, Hist. British Infusoria, Ed. 4, 1861, p. 903; new name for *N. punctulata* W. SMITH, not EHRENBERG.—VAN HEURCK, Syn. Diat. Belgique, 1880-1881, pl. 11, fig. 16.—Not *N. marina* JANISCH & RABENHORST, Diat. Honduras, 1863, p. 10, pl. 2, fig. 16.

Navicula punctulata W. SMITH, Syn. British Diat., vol. 1, 1853, p. 52, pl. 16, fig. 151; Marine, Poole Bay and Seaford, Sussex, England.—Not *N. punctulata* EHRENBERG, Monatsber. Akad. Wiss. Berlin, 1842, p. 337; Mikrog., 1854, pl. 16, group 1, fig. 1; pl. 15A , fig. 34; pl. 15B, fig. 14.

Navicula granulata BREBISSON, VAN HEURCK, Syn. Diat. Belgique, 1880-1881, pl. 11, fig. 15.—Not *N. granulata* BREBISSON, in DONKIN, Trans. Micr. Soc., vol. 6, n. s., 1858, p. 17, pl. 3, figs. 19 *a*, *b*.

Navicula schultzei KAIN, Bull. Torrey Bot. Club, vol. 16, 1889, p. 75, pl. 89, fig. 2, Atlantic City, New Jersey, Miocene.

Navicula schultzei mexicana SCHMIDT, Atlas Diat., pl. 244, 1903, fig. 5.

This species is very common in the Kettleman Hills deposit. Much variation in shape is apparent and this is a feature noted by several other writers, in this and closely related species. The beading, however, is uniformly heavy and coarse. The most common shape is the plain oval (fig. 6) corresponding to W. Smith's original figure. The quadrangular and capitate forms are not so common.

The synonymy of this species is decidedly complicated. We have restricted our application of the name to those forms having very coarse beads, the maximum number in any transverse line being about 10. This permits the exclusion of those diatoms similar in shape but much finer marked and to which the following names have

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EXPLANATION OF PLATE 13

FIG. 1.—*Hyalodiscus schmidtii* Frenguelli. Plesiotype, No. 3,075 (Calif. Acad. Sci.), ×740; diameter, .0660 mm.

2.—*Hyalodiscus schmidtii* Frenguelli. Same specimen as fig. 1 but with a lower focus to show convexity.

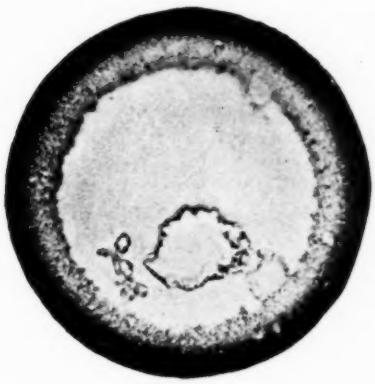
3.—*Hyalodiscus schmidtii* Frenguelli; diagrammatic side view.

4.—*Hyalodiscus schmidtii* Frenguelli; details of sculpture. Plesiotype, No. 3,076 (Calif. Acad. Sci.).

5.—*Navicula smithii* Brebisson. Plesiotype, No. 3,081 (Calif. Acad. Sci.), ×1,250; length, .0518 mm.; width, .0295 mm.

6.—*Navicula marina* Ralfs. Plesiotype, No. 3,078 (Calif. Acad. Sci.), ×1,100; length, .0662 mm.; width, .0350 mm.

7.—*Navicula marina* Ralfs. Pleisotype, No. 3,079 (Calif. Acad. Sci.), ×1,150; length, .0492 mm.; width, .0322 mm.



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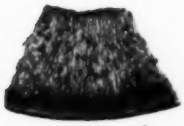

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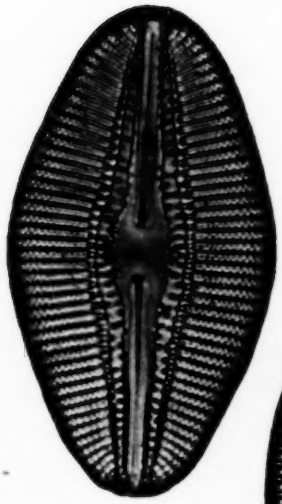

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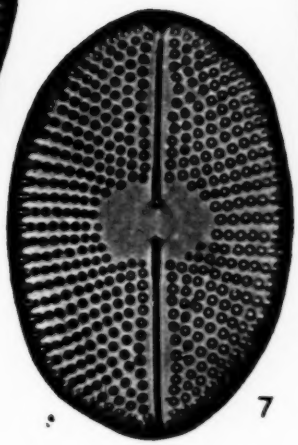

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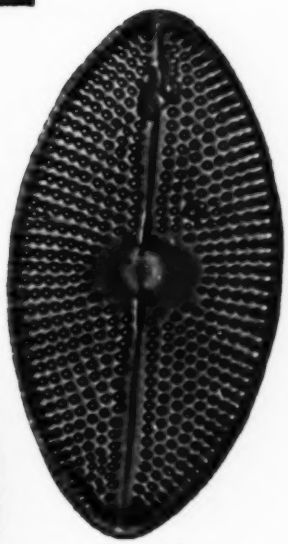

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been given: *N. granulata*[4], *N. maculata* (Bailey)[5]; and *N. granulata* Bailey[6]. The first has much finer beads and no stauros; the second has many more beads in a transverse row; and the third has a smaller stauros, more beads in the transverse rows than *N. marina* and each half of the raphe is spindle-shaped. Various other names have been given to the finely marked forms but these three are the most important in the present case because coarsely marked diatoms have been referred to them.

NAVICULA SMITHII Brebisson

Plate 13, fig. 5

Navicula smithii BREBISSON, in W. SMITH, Syn. Brit. Diat., vol. 2, 1856, p. 92.—SCHMIDT, Atlas Diat., pl. 7, 1875, figs. 14-20.—VAN HEURCK, Syn. Diat. Belgique, 1880-1881, pl. 9, fig. 12, supp. 1, fig. 23*.—VAN HEURCK, Treat. Diat., 1896, p. 197, pl. 4, figs. 151 *a*, *b*.—MANN, Cont. U. S. Nat. Herb., vol. 10, 1907, p. 354.

Many different forms have been listed and drawn to represent *N. smithii* and it is doubtful if all can prove to be the same. However, most of the figures are so poor that certainty of identification can hardly be attempted until the entire group is recast. Apparently it has been the practice to refer most elliptic forms having double rows of beads for costae, to this name, other details having been ignored; such pictures as the one shown herewith are necessary to enable the student to understand the form in hand. The species is variable as to size in the Kettleman Hills deposit but the form and details of sculpture are remarkably constant. The specimen illustrated is of average size. An idea of the complicated synonymy pertaining to the species can be had from the account given by Dr. Mann, cited above.

NAVICULA SOLARIS Gregory

Plate 14, fig. 2

Navicula solaris GREGORY, Trans. Micr. Soc. London, vol. 4, n. s., 1856, p. 43, pl. 5, fig. 10.—SCHMIDT, Atlas Diat., pl. 46, 1876, fig. 16.—WOLLE, Diat. N. Amer., 1890, pl. 17, fig. 6.—VAN HEURCK, Treat. Diat., 1896, p. 186, pl. 25, fig. 717.—MANN, Cont. U. S. Nat. Herb., vol. 10, 1907, p. 355.

Many diatoms of the general form of this have been described and figured but the drawings are usually on such a small scale that they are useless for identification purposes. Some of the figures cited show a diatom more rhomboidal than our specimens but agreement

[4] Brebisson, in Donkin *Trans. Micr. Soc.*, vol. 6, n. s. (1858), p. 17, pl. 3, figs. 19, *a*, *b*.
[5] *Smith. Cont. Know.*, vol. 2, no. 8 (1851), p. 40, pl. 2, fig. 32.
[6] *Smith. Cont. Know.*, vol. 7 (1855), p. 10, fig. 16; [genus name spelled *Naviculata* by error].

is closer than with any of the other named forms closely related. The species is rare in the sediments studied from the Kettleman Hills.

NITZSCHIA ETCHEGOINIA Hanna and Grant, n. sp.

Plate 14, fig. 3

Valves a little more than twice as long as broad, slightly constricted on dorsal side; ends roundly pointed; in the center of the valve there is a longitudinal depression, strongest in the axis and fading away imperceptibly toward each end; surface marked with a series of heavy, close-set, irregularly shaped and spaced maculations; with objectives of very high aperture there is also seen to be a series of close-set, very fine horizontal lines, resolvable into beads under the most favorable conditions. Length, .0840 mm.; width, .0330 mm.

Holotype (No. 3083, Calif. Acad. Sci.) from Loc. 969, Kettleman Hills, Fresno County, Calif.; Etchegoin, Pliocene.

Some of the specimens of this abundant species show a median constriction on the ventral as well as the dorsal side. The coarse, irregular maculations are all the surface markings visible with dry objectives and this conspicuous feature has not been noted in the literature as pertaining to any other *Nitzschia*. These are well shown in fig. 3. The excessively fine transverse lines of beads can only be seen by careful manipulation with the best lenses. The species is obviously related to the widely spread *N. tryblionella* (Hantzsch) but in no form of this do the coarse striae appear to be replaced with such a series of maculations as has been described. If a single specimen so marked were found it would be considered to be pathologic but such an assumption in this case is unwarranted; the form is very abundant and very constant in all its characters.

NITZSCHIA GRANULATA Grunow

Plate 14, fig. 4

Nitzschia granulata GRUNOW, Mon. Micr. Journ., 1880, p. 395, pl. 12, fig. 7.—VAN HEURCK, Syn. Diat. Beligique, 1880-1881, pl. 57, fig. 5.—WOLLE, Diat. N. Amer., 1890, pl. 43, fig. 11; the author says this is *Pyxidicula compressa* BAILEY, Micr. Obs., 1851, p. 40, pl. 2, figs. 13, 14; if so, the latter name should take precedence.

This coarsely marked *Nitzschia* is common in the Kettleman Hills deposit. No differences could be detected between the specimens and those found living in various brackish waters along the coast of California.

SURIRELLA STRIATULA Turpin

Plate 14, fig. 5

Surirella striatula TURPIN, Mem. Mus. Hist. Natur., vol. 16, 1828.—KÜTZING, Bacill., 1844, pl. 7, fig. 6.—EHRENBERG, Mikrog., 1854, pl. 10, group 2, fig. 10.—SCHMIDT, Atlas, Diat., pl. 24, 1875, fig. 17; [Salt Lake, Utah].—WOLLE, Diat. N. Amer., 1890, pl. 55, fig. 6.—VAN HEURCK, Treat. Diat., 1896, p. 371, pl. 13, fig. 580.

The specimens found are not quite as broad in proportion to length as most of those previously figured. Otherwise relationship appears sufficiently close to permit this identification. The form is rare in the Kettleman Hills deposit.

SURIRELLA UTAHENSIS Grunow

Plate 14, fig. 6

Surirella ovata utahensis GRUNOW, SCHMIDT, Atlas Diat., pl. 24, 1875, figs. 11-13; [Salt Lake, Utah].

Surirella ovalis KÜTZING, WOLLE, Diat. N. Amer., 1890, pl. 53, fig. 5.

Grunow evidently separated this species from *S. ovata* Kützing, *ovalis* Brebisson and their numerous named varieties, partly because it does not possess a central hyaline area. An examination of the numerous figures of the named forms does not indicate that *utahensis* intergrades; therefore it should be entitled to separate specific rank. The species is very common in the Kettleman Hills deposit.

EXPLANATION OF PLATE 14

FIG. 1.—*Navicula marina* Ralfs. Plesiotype, No. 3,080 (Calif. Acad. Sci.), ×1,150; length, .0626 mm.; width, .0327 mm.

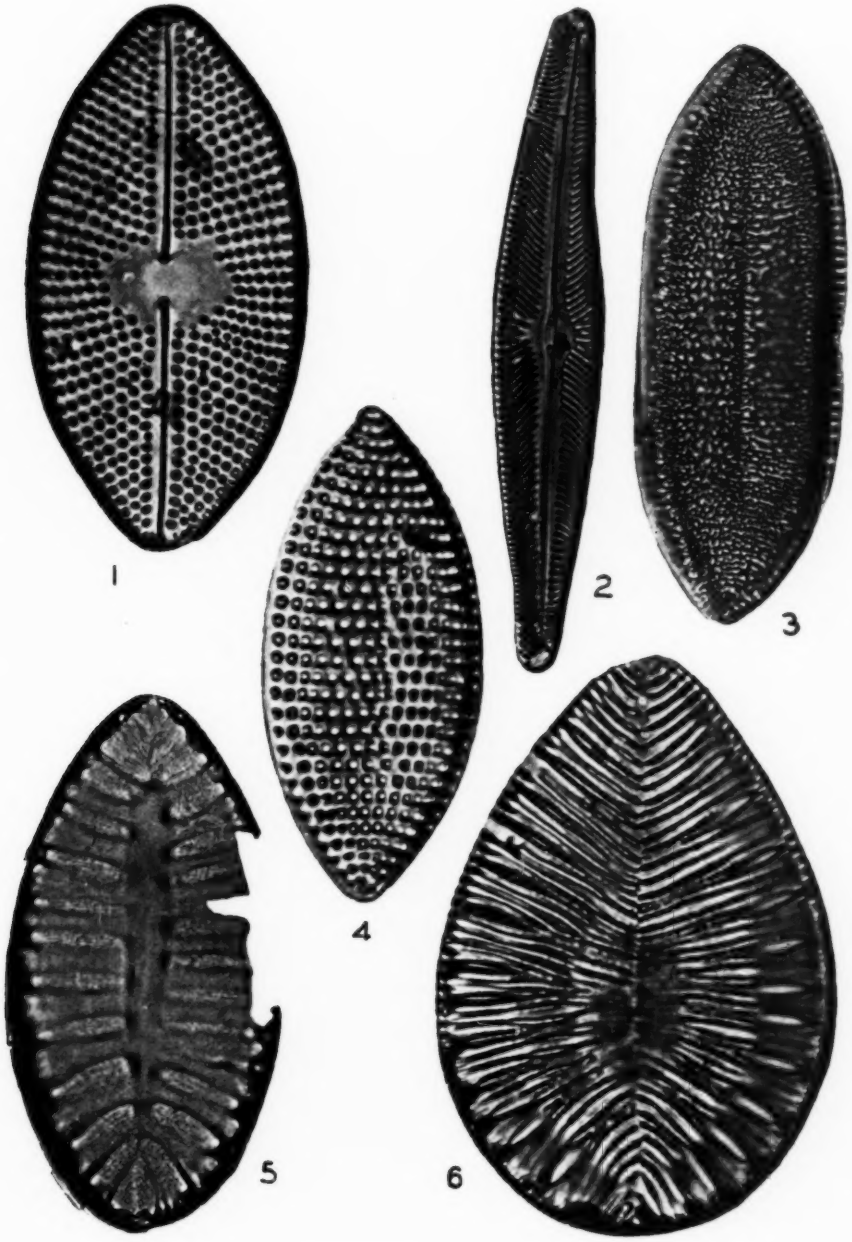
2.—*Navicula solaris* Gregory. Plesiotype, No. 3,082 (Calif. Acad. Sci.), ×880; length, .1034 mm.; width, .0190 mm.

3.—*Nitzschia etchegoinia* Hanna and Grant, n. sp. Holotype, No. 3,083 (Calif. Acad. Sci.), ×920; length, .0840 mm.; width, .0330 mm.

4.—*Nitzschia granulata* Grunow. Plesiotype, No. 3,084 (Calif. Acad. Sci.), ×1,700; length, .0387 mm.; width, .0168 mm.

5.—*Surirella striatula* Turpin. Plesiotype, No. 3,085 (Calif. Acad. Sci.), ×620; length, .1150 mm.; width, .060 mm.

6.—*Surirella utahensis* Grunow. Plesiotype, No. 3,086 (Calif. Acad. Sci.), ×1,600; length, .0489 mm.; width, .0345 mm.



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A CORRECTION OF NAME

By H. C. VANDERPOOL

Laredo, Texas

Drs. T. W. Stanton and L. W. Stephenson of the U. S. Geological Survey have identified as *Ostrea camelina* Cragin, the fossils which I called *Ostrea subspatulata* Forbes in the megafauna check list of my paper on the "Fossils from the Trinity Group (Lower Comanchean)", Volume 2, No. 2, June 1928, of this Journal.

The phrase "are usually quite fossiliferous" should be added to the end of the first sentence in this same paper.

ACTIVITIES OF THE SECTIONS OF THE SOCIETY OF ECONOMIC PALEONTOLOGISTS AND MINERALOGISTS

Pacific Section

The paleontologists of the Pacific Coast have an active and enthusiastic section of the Society of Economic Paleontologists and Mineralogists. Mr. Stanley G. Wissler of the Research Department of the Union Oil Company of California is chairman, and Mr. R. B. Hutcheson of the same department is secretary. The section holds meetings on the first of each month at the Engineers Club, Los Angeles. The first meeting for the season of 1928-29 was held September 6. About thirty paleontologists from the universities located in southern California and from the laboratories of the oil companies were present and attended a dinner served at 6:30. This was followed by a program consisting of an excellent paper by Mr. R. B. Hutcheson on the Malaga Cove section, Los Angeles County, and another by G. C. Kuffel of the Union Oil Company on the Santa Barbara Beach fauna, Santa Barbara County. On October 4, Mr. G. H. Doane and Mr. L. S. Chambers of the Milham Exploration Company delivered a paper on the Adams Canyon section, Ventura County.

On November 1, Mr. Paul P. Goudkoff discussed the Kalerma Canyon section, Ventura County. On December 6, Mr. Guy Miller and Mr. E. M. Savage of the Shell Oil Company reported on the Newport section, Orange County; and on January 3, Messrs. H. L. Driver, W. H. Holman, and A. Ferrando of the Standard Oil Company read a paper on the Repetto Hills section, Los Angeles County. The authors of each of these papers prepared maps and diagrams showing the geologic traverses, geologic sections, and faunal charts, and presented slides showing each species of fossil collected. These diagrams and charts and slides were distributed to the paleontologists present at the meetings.

North Texas Section

The north Texas section holds meetings on the first of each month in the laboratory of Texas Christian University, Fort Worth. Mr. Norman Thomas of Pure Oil Company is president, and Mr. Frank Stangl of Texas Christian University is secretary. At the first meeting of the society Mrs. Esther Applin gave an interesting paper on the Yegua formation of the Gulf Coast. At the second meeting Dr. C. I. Alexander of Princeton and Texas Christian universities presented a digest of his doctor's thesis on the ostracods of the Cretaceous formations of north Texas. At the December meeting Mr. J. A. Waters of the Sun Oil Company, Dallas, and Mr. Merlin Upson of the Gulf Production Company, Fort Worth, read papers on the microfaunas of the Cisco formations of the Pennsylvanian.

RESEARCHES BY MEMBERS OF THE SOCIETY OF ECONOMIC PALEONTOLOGISTS AND MINERALOGISTS

Dr. C. I. Alexander, an assistant professor in the Geological Department of Texas Christian University, has completed a paper on the ostracods of the Cretaceous formations of Texas. This paper was the subject of his doctor's thesis at Princeton University. He is now studying the foraminifera of the Fredricksburg division.

Mr. W. L. Moreman, assistant in the Department of Geology at the University of Kansas, is engaged in a study of the fauna and stratigraphy of the Eagleford formation of Texas.

Dr. John R. Sandidge, instructor in micro-paleontology at Princeton University, has completed a study of the foraminifera of the Ripley formation of Alabama as a doctor's thesis at Johns Hopkins University.

Miss Julia Gardner of the United States Geological Survey has in press a bulletin on the large fossils of the Midway formation of the Gulf Coast.

Mr. Fred Brasted, an assistant in the Department of Geology at the University of Iowa, has undertaken an extensive study of the origin and sedimentation of the oil sands of the Cisco division of the

Pennsylvanian of Texas. This research is sponsored by committees appointed by the Society of Economic Paleontologists and Mineralogists and American Association of Petroleum Geologists to promote investigations in Permo-Carboniferous geology and is to be carried out under the direction of Prof. A. C. Trowbridge.

Mr. W. S. Adkins of the Bureau of Economic Geology, University of Texas, has completed a bulletin, "Handbook of Texas Cretaceous Fossils", containing 385 pages and 37 plates. This publication is now just off the press as Bulletin No. 2838 of the University of Texas.

Dr. Gayle Scott, Professor of Geology at Texas Christian University, is engaged in a study of the ammonites of the Pennsylvanian formations of Texas as an aid to correlation of Mid-continent formations.

Mr. Norman Thomas of the Geological Department of Pure Oil Company is collaborating with Dr. J. A. Cushman on a study of the foraminifera of the Cook Mountain formation of Texas.

Dr. Henry V. Howe, Professor of Geology at Louisiana State University, has been engaged for some time on a study of the faunas of the Claiborne formations of the Gulf Coast.

Mr. Jerome Smiser, graduate student at Texas Christian University, is studying echinoid fragmentals of the Cretaceous.

Mrs. Helen J. Plummer is now working on the foraminifera of the Navarro formation of Texas. She has recently prepared a short paper on the preparation of a photographic slide mount for minute fossils.

Dr. J. W. Beede of the University of Indiana is engaged in an extensive study of Permian Fusulinidae of Kansas, Oklahoma, and Texas.

Dr. Margaret Fuller Boos has prepared for publication a paper on the marine Permian fauna of the Luta limestone of Kansas.

Miss Minette Ries, graduate student in the University of Texas, is preparing under the direction of Professor Whitney a paper on the fauna of the Glen Rose formation of the Lower Cretaceous.

Mr. Philip King, graduate student at Yale University, is working on the fauna of the Permian formation of the Glass Mountains of Texas as a doctor's thesis.

Dr. Lloyd W. Stephenson of the United States Geological Survey has taken up the study of the fauna of the larger fossils of the Navarro formation of Texas. This work will be carried on as a joint enterprise of the United States Geological Survey and the Bureau of Economic Geology, University of Texas.

ABSTRACTS AND REVIEWS OF RECENT PALEONTOLOGIC LITERATURE

ADKINS, W. S. Handbook of Texas Cretaceous fossils: Univ. of Texas, Bull. 2838; 385 pp. 1928.

This useful book presents illustrations and concise descriptions of practically all the fossils of the lower and upper Cretaceous of Texas with notation of geographic and geologic distribution. It includes plants, invertebrates, and vertebrates, biologically arranged. Important zone fossils are distinguished and a correlation table of the Texas Cretaceous formations is presented. Faunal lists are arranged also by formations. The plan of the work and use of keys for identification of fossils adds to general usefulness, especially for the student, professional or layman, who is not familiar with Cretaceous fossils. The handbook may be obtained from the Bureau of Economic Geology, Austin, Texas; price, one dollar. R. C. M.

COLE, W. STORRS. A Foraminiferal fauna from the Chapapote formation in Mexico: Bull. American Paleontology, vol. 14, no. 53: 1-32, 1928.

Records fifty-eight species and varieties of which thirteen are described as new.

CUSHMAN, JOSEPH A. Additional genera of the Foraminifera: Contr. Cushman Lab. Foraminiferal Research, vol. 4, part 1: 1-8, 1928.

Describes the following eleven new genera and one species in each of the first two: *Flabellammina*, Lower Cretaceous of Texas; *Ventilabrella*, Upper Cretaceous of Texas; *Neocribrella*, Eocene of France; *Epistomella*, Eocene to Recent; *Patellinella*, *Cymbaloporetta*, Tertiary and Recent; *Cornuspiroides*, *Cornuspirella*, *Cornuspiramia*, *Planorbulinoides*, *Normanina*, all Recent. The new name *Ammovertella* is proposed for Schellwien's *Psammophis* of the Carboniferous, which is preoccupied. R. C. M.

CUSHMAN, JOSEPH A. Apertural characters in the Lagenidae: Contr. Cushman Lab. Foraminiferal Research, vol. 4, part 1: 22-26, 1928.

Study of apertural characters of the Lagenidae indicates that in this plastic group, as in other foraminifera, coiled forms are primitive as a rule. A supplementary apertural chamberlet, with outer aperture radiate and inner aperture simple, is developed in several forms. R. C. M.

CUSHMAN, JOSEPH A. A peculiar *Clavulina* from the Upper Cretaceous of Texas: Contr. Cushman Lab. Foraminiferal Research, vol. 4, part 3: 61-62, 1928.

A new species of foraminifera from just above the Nacatoch Sand of the Navarro, Upper Cretaceous, in a well in the Mexia field, Texas. R. C. M.

CUSHMAN, JOSEPH A. The microspheric and megalospheric form of *Apterrinella grahamensis*: Contr. Cushman Lab. Foraminiferal Research, vol. 4, part 3: 66-69, 1928.

Describes structure and trimorphic variations of a Pennsylvanian foraminifer of Texas and Oklahoma. R. C. M.

CUSHMAN, JOSEPH A. A Cretaceous *Cyclammina* from California. Contr. Cushman Lab. Foraminiferal Research, vol. 4, part 3: 70-71, 1928.

Describes large new species of foraminifera widely distributed at an horizon near top of the Cretaceous in California. R. C. M.

CUSHMAN, J. A. Additional Foraminifera from the upper Eocene of Alabama: Contr. Cushman Lab. Foraminiferal Research, vol. 4, part 3: 73-79, 1928.

Indicates composition of a moderately deep water foraminiferal fauna, of Upper Eocene age, near Cocoa, Ala., and describes four new species. R. C. M.

CUSHMAN, J. A. On *Rotalia Beccarii* (Linné): Contr. Cushman Lab. Foraminiferal Research, vol. 4, part 4: 103-107, 1928.

This species, widely reported from certain oil field strata, is described and illustrated from type locality (Rimini on the Adriatic) material. Many of the forms that have been identified with this species are really distinct. R. C. M.

CUSHMAN, J. A. Fistulose species of *Gaudryina* and *Heterostomella*: Contr. Cushman Lab. Foraminiferal Research, vol. 4, part 4: 107-112, 1928.

Describes two Cretaceous (one new) and one Recent species of foraminifera, the former from Texas. R. C. M.

CUSHMAN J. A. and JARVIS, P. W. Cretaceous Foraminifera from Trinidad: Contr. Cushman Lab. Foraminiferal Research, vol. 4, part 4: 85-103, 1928.

Describes Upper Cretaceous foraminiferal fauna of forty-one species and varieties, of which ten are new. Closely related to the Velasco shale of the Tampico region of Mexico. R. C. M.

CUSHMAN, J. A. and OZAWA, YOSHIAKI. An outline of a revision of the Polymorphinidae: Contr. Cushman Lab. Foraminiferal Research, vol. 4, part 1: 13-21, 1928.

A study of one of the families of foraminifera, including brief description of nine genera. Four new genera and two subgenera, as follows, are described: *Pseudopolymorphina* (Jurassic to Recent), *Pyrulinella* (Jurassic to Recent), *Sigmomorpha* and subgenus *Sigmomorphina* (Recent), *Sigmoidella* and subgenus *Sigmoidina* (Recent). Six new species, from Japan and the China sea. A diagrammatic phylogenetic classification is presented. R. C. M.

CUSHMAN, JOSEPH A. and WATERS, JAMES A. Some Foraminifera from the Pennsylvanian and Permian of Texas: Contr. Cushman Lab. Foraminiferal Research, vol. 4, part 2: 31-55, 1928.

An important paper describing nine new genera and twenty-eight new species of Pennsylvanian and Permian foraminifera from the oil fields of north Texas. Arenaceous forms dominate the calcareous type, but in Upper Pennsylvanian and Permian the latter increase notably. Arenaceous foraminifera from black shales,

representing brackish or acid conditions, show a strong development of the inner chitinous layer, as under similar conditions at present. The new genera are as follows: *Hyperamminella, Trepeilopsis, Orthovertella, Calcitornella, Calcivertella, Plummerinella, Mooreinella, Polytaxis* and *Glyphostomella.* R. C. M.

CUSHMAN, JOSEPH A. and WATERS, JAMES A. Additional Cisco Foraminifera from Texas: Contr. Cushman Lab. Foraminiferal Research, vol. 4, part 3: 62-67, 1928.

Describes one new genus, *Apterrinella,* and eight new species from the Upper Pennsylvanian of north Texas. R. C. M.

CUSHMAN, JOSEPH A. and WATERS, JAMES A. *Hyperamminoides,* a new name for *Hyperamminella* Cushman and Waters: Contr. Cushman Lab. Foraminiferal Research, vol. 4, part 4: 112, 1928.

Correction of the name of a Pennsylvanian foraminifer. R. C. M.

CUSHMAN, J. A. and WICKENDEN, R. T. D. A new Foraminiferal genus from the Upper Cretaceous: Contr. Cushman Lab. Foraminiferal Research, vol. 4, part 1: 12-13, 1928.

Describes the new genus *Neobulimina* and a species from the Upper Cretaceous of Canada. It differs from *Bulimina* in having a biserial adult portion and slightly different aperture. R. C. M.

HERON-ALLEN, EDWARD and EARLAND, ARTHUR. On the Pegididae, a new family of Foraminifera: Jour. Roy. Micr. Soc., vol. 48: 283-299, 1928.

Four new genera and a number of new species are described. R. C. M.

HOFKER, J. On *Faujasina* D'Orbigny: Contr. Cushman Lab. Foraminiferal Research, vol. 4, part 3: 80-83, 1928.

Morphologic characters, especially development of the canal system, indicate derivation of *Faujasina* from *Elphidium.* R. C. M.

KOCH, RICHARD. Tertiärer Foraminiferenkalk von der Insel Curacao (Niederländisch West-Indian): Eclogae Geologicae Helvetiae, vol. 21, no. 1· 51-56, 1928.

Describes new species of *Lepidocyclina* and gives notes on other species. R. C. M.

MOBERG, M. WILCOX. New species of *Coskinolina* and *Dictyoconus* from Florida: Florida Geol. Survey 19th Ann. Rept: 166-175, 1928.

A new species of each genus from Eocene beds is described and figured. R. C. M.

MUIR-WOOD, HELEN M. The British Carboniferous *Producti,* II. *Productus (sensu stricto); Semireticulatus* and *Longispinus* groups: Memoirs Geol. Survey Great Britain, vol. 3, part 1: 1-217; plates 1-12, Dec., 1928.

This interesting and valuable contribution continues the studies on the Carboniferous *Producti* undertaken by the late Dr. Ivor Thomas, whose first paper with detailed discussion of the genera *Pustula* and *Overtonia* appeared in 1914. Following a precise outline of terminology in which some new morphologic terms are introduced, there is an extended discussion of the growth stages of the *Producti,* their habits, evolution and range. According to the author, the Carbonif-

erous *Producti* lend themselves to division into at least eight distinct genera by means of their external ornaments and internal characters. These are as follows: *Productus, Avonia, Buxtonia, Sinuatella, Proboscidella, Etheridgina, Pustula, Overtonia*, all but the last two being redefined in this paper. The genus *Sinuatella* is new. *Productus*, as revised, includes the *P. semireticulatus* and *P. longispinus* groups and with the various British representatives of these the author is here concerned. In addition, there are a number of other more or less distinct groups of species now assigned to *Productus s. s.* which may possibly be designated in future as separate genera or subgenera. In the *P. semireticulatus* group thirty species and varieties are described, sixteen of which are new. In the *P. longispinus* group there are eleven species and varieties, seven of which are new. All of the shells described come from horizons in the Lower Carboniferous of Great Britain, excepting possibly those from the Pendleside and Yoredalian beds which are uppermost Lower Carboniferous or may perhaps be included in the lower part of the Upper Carboniferous. American forms from the Pennsylvanian which have been identified more or less frequently as *L. longispinus, P. semireticulatus*, and *P. costatus* are reported by the author to be distinct from the type forms of these species from the British Lower Carboniferous. R. C. M.

E. NEAVERSON, Stratigraphical Palaeontology, 525 pp., 70 fig., MacMillan and Co., London, 1928.

This attractive addition to paleontologic textbooks undertakes to cover analytically the field of biostratigraphy,—the composition and distinguishing characters of successive faunas and floras that have been preserved in the fossil record. Designed for the British student, the book naturally deals with the fossil-bearing beds of the British Isles. Description of the paleontologic characteristics of the very numerous faunal zones that have been recognized and discussion of the interrelation of provincial districts are apparently not only very well adapted to the needs of the author's countrymen, but afford welcome opportunity to foreign workers for comparative study in this field. About five hundred of the more diagnostic fossils are illustrated, the majority by well executed pen drawings. However, many species, including zone fossils, are not figured. A good bibliography follows each of the chapters. There is almost no attempt to consider correlation of the British faunas with those of the European continent, America or other parts of the world, and the book is accordingly somewhat less useful as a general treatise.

The first portion of the book (174 pages) is devoted to a brief outline of the morphological features of the chief fossil groups, preservation and occurrence of fossils, geographical distribution and migration of faunas and their relation to habitat, and fossils as indices of horizon. The first of these subjects is necessarily so condensed that it hardly serves the beginning student and it may be doubted whether a summary of this nature is required by the advanced student prepared to attack the stratigraphic survey of faunas.

The American paleontologist will find much of value in Neaverson's work, but it is hoped that, in response to a need expressed by many students in this country, a somewhat similar outline of stratigraphic paleontology based on the remarkable faunal development of the North American geologic column, may be made available. R. C. M.

NUTTALL, W. L. F. Tertiary Foraminifera from the Naparima region of Trinidad (British West Indies): Quart. Jour. Geol. Soc., vol. 84: 50-57, 112, 1928.

There are 144 species noted of which 16 are new. Excellently illustrated. R. C. M.

OZAWA, YOSHIAKI. A new genus, *Depratella*, and its relation to *Endothyra*: Contr. Cushman Lab. Foraminiferal Research, vol. 4, part 1: 9-10, 1928.

Proposes the name *Depratella* for certain Permian fusulinids, originally assigned by Deprat to *Neofusulinella*, which now appears synonymous with *Fusulinella*. Some specimens of *Endothyra* from British Lower Carboniferous show thin, nearly non-arenaceous walls, and this genus undoubtedly gave rise to *Staffella* and *Depratella*. R. C. M.

SILVESTRI, AL. Nummuliti, operculina e planorbulina di Derna nella Cirenaica: Mem. Pont. Accad. Sci., Nuovi Lincei, vol. 11: 263-278, 1928.

Several Tertiary foraminiferal species are described and beautifully figured. R. C. M.

VAN DER VLERK, I. M. The genus *Lepidocyclina* in the Far East: Eclogae Geologicae Helvetiae, vol. 21, no. 1, 182-211, 1928.

Describes fifty species and varieties with one new subgenus and one new species. R. C. M.

VAUGHAN, T. W. New species of *Operculina* and *Discocyclina* from the Ocala limestone: Florida Geol. Survey 19th Ann. Rept: 155-165, 1928.

The larger foraminifera of the Ocala limestone (Eocene) of Florida are listed and briefly discussed; four new species described. R. C. M.

WHITNEY, F. L. Bibliography and Index of North American Mesozoic Invertebrata: Bull. Amer. Paleontology, vol. 12, no. 48: 448 pp., 1928.

Alphabetically arranged under genera and species, giving reference to stratigraphic horizon and localities. R. C. M.

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